

North Atlantic coast of the USA – sea level change vulnerability and adaptation measures

Presentation to iGLASS on US North Atlantic coast SLC issues

January 7th, 2014

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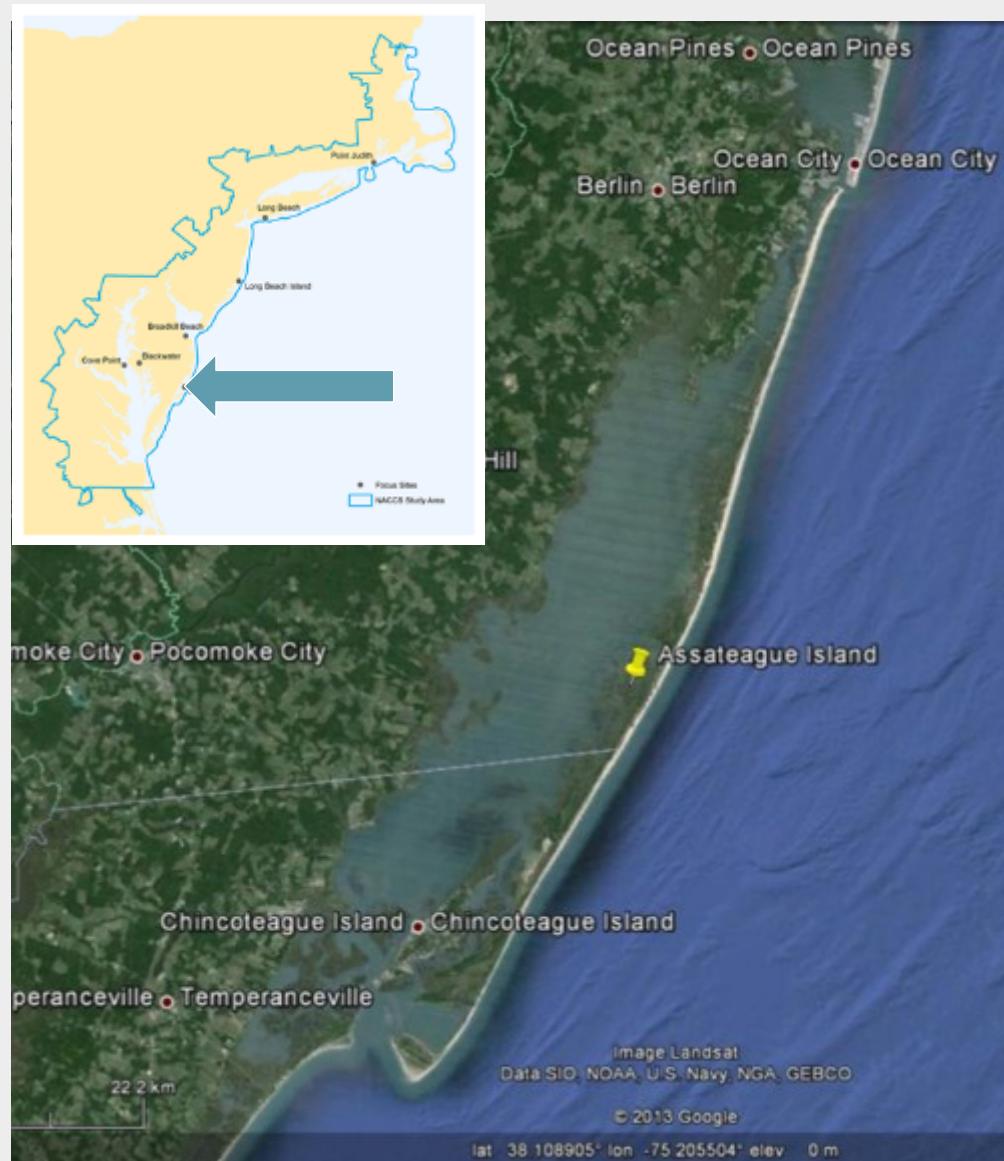
Report Documentation Page			Form Approved OMB No. 0704-0188	
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1. REPORT DATE 07 JAN 2014	2. REPORT TYPE		3. DATES COVERED 00-00-2014 to 00-00-2014	
4. TITLE AND SUBTITLE North Atlantic coast of the USA - sea level change vulnerability and adaptation measures			5a. CONTRACT NUMBER W911NF-13-1-0453	5b. GRANT NUMBER
			5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)			5d. PROJECT NUMBER	5e. TASK NUMBER
			5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) HR Wallingford, Howbery Park, Wallingford, UK,			8. PERFORMING ORGANIZATION REPORT NUMBER ; 1666-EN-01	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Army Engineer Research & Development Center - International Research Office, ERDC-IRO, ATT: RICHMOND, Unit 4507, APO, AE, 09421			10. SPONSOR/MONITOR'S ACRONYM(S)	11. SPONSOR/MONITOR'S REPORT NUMBER(S) 1666-EN-01
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited				
13. SUPPLEMENTARY NOTES				
14. ABSTRACT				
15. SUBJECT TERMS				
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 43
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified	19a. NAME OF RESPONSIBLE PERSON	

- Progress in evaluating the 7 sites
 - Land profile analysis
 - Submergence analysis and impact of sea level change
 - SLOSH analysis and how to evaluate impact of SLC on this
 - Comments on Blackwater National refuge
- Discussion on selecting measures and the approach to their evaluation





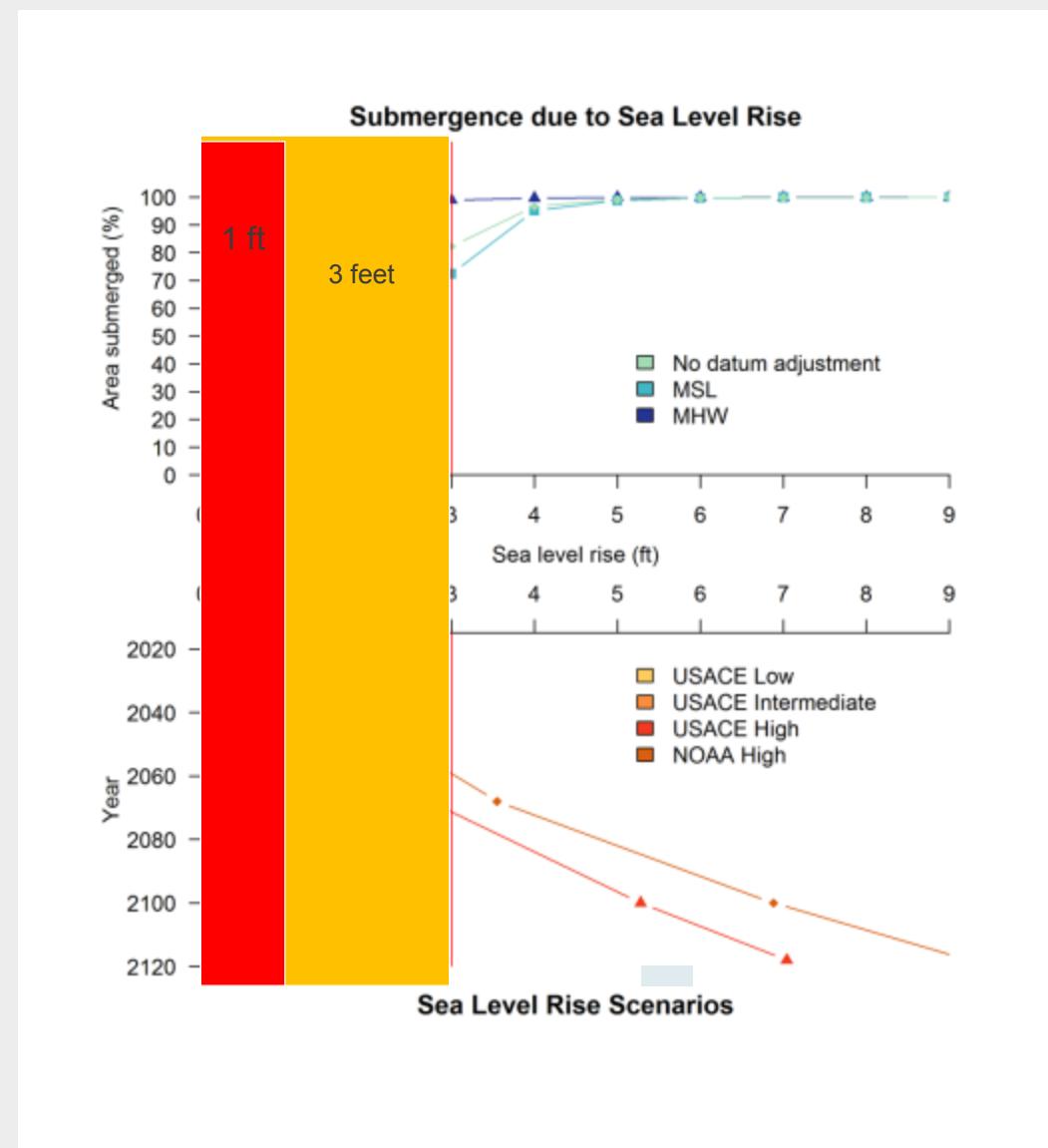
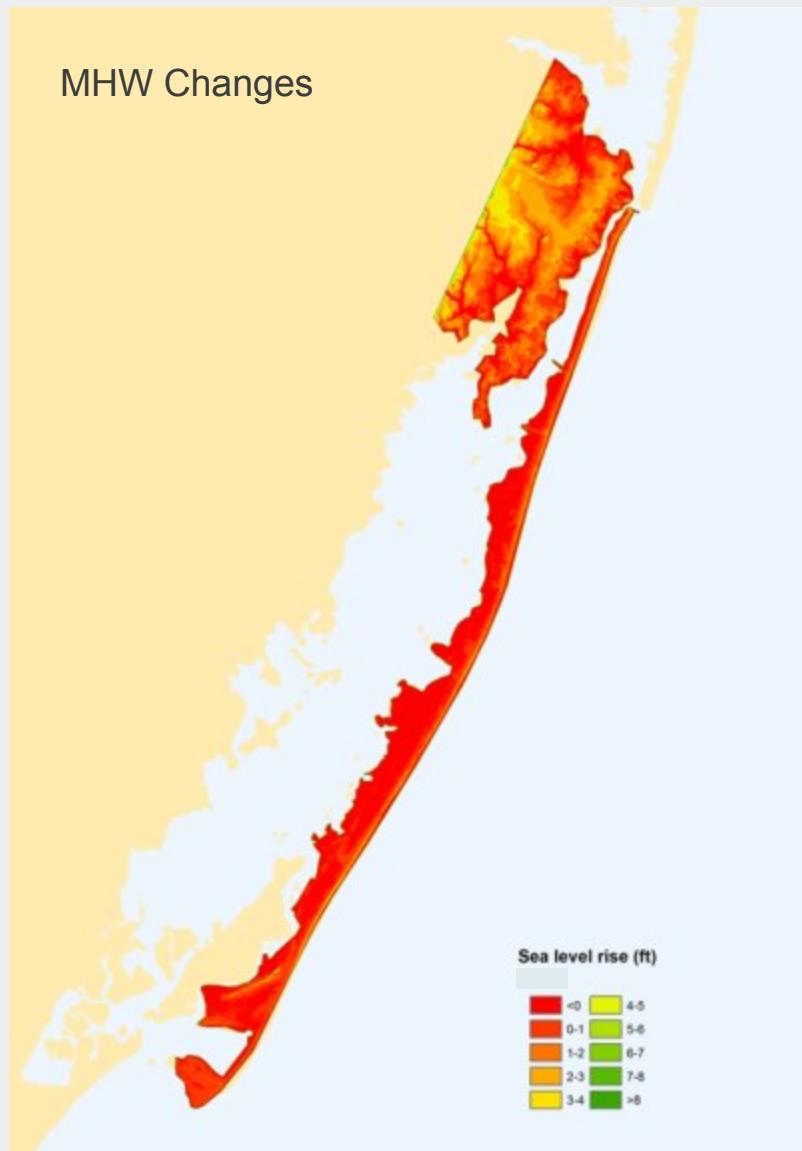
Assateague Island, MD / VA



General issues for barrier islands

- Barrier islands naturally migrate in response to sediment supply, prevailing wind conditions, tidal currents and severe storm actions.
- Migration is defence against sea level rise, as they can naturally reshape in response to the coastal process changes.
- Addition of permanent infrastructure and expecting infrastructure to be defended is counter-productive cf. resilience of holistic coastline communities

Assateague Island - submergence



A 'tale of two halves'

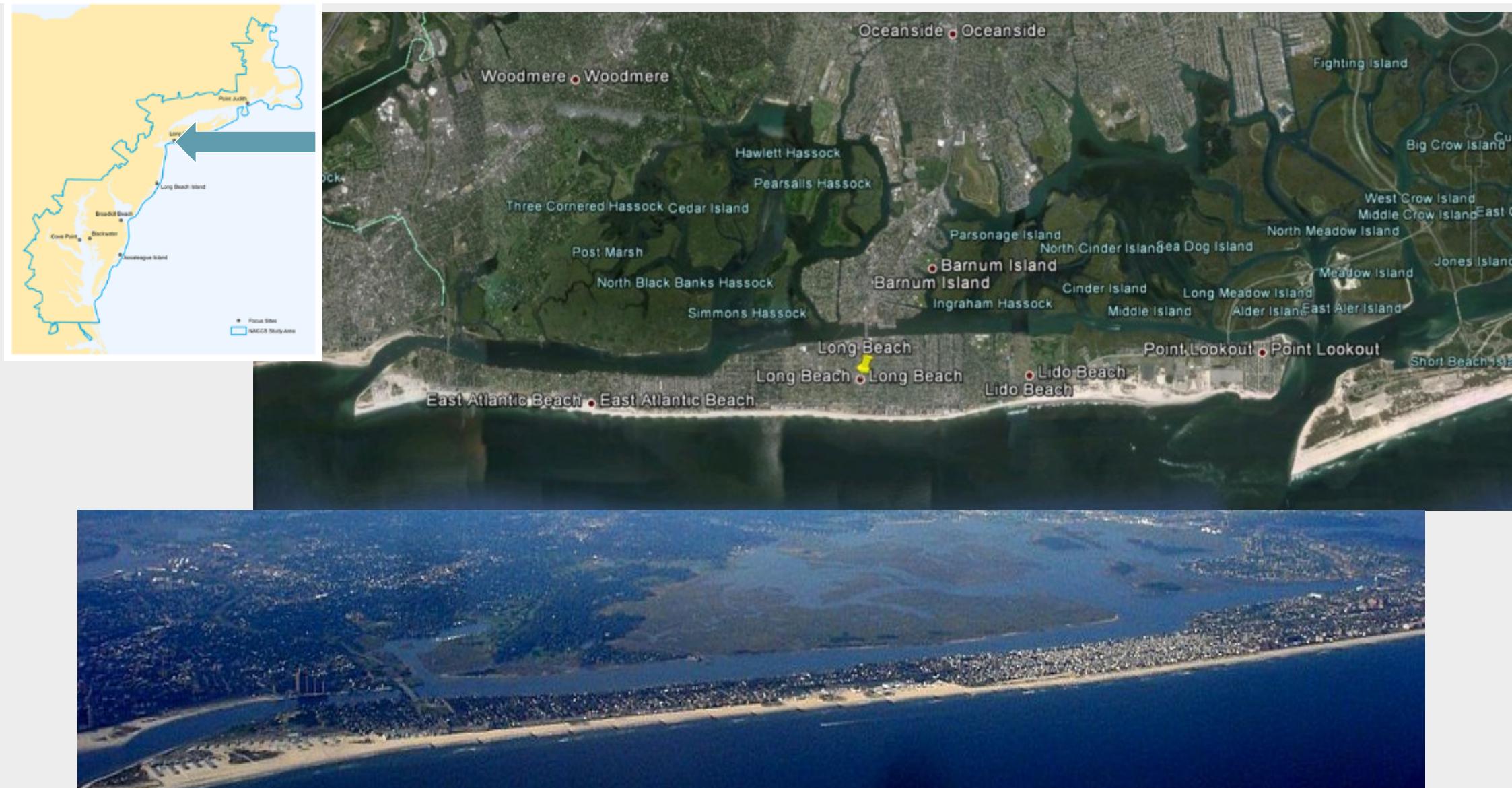
- breach channel in front of Ocean City formed during 1933 hurricane.
- breach channel maintained by jetties and dredging, in order to provide navigational access to Ocean City.
- longshore sediment drift during normal weather conditions disrupted
- Hence, migration of north and south parts of Assateague very different

Strategies

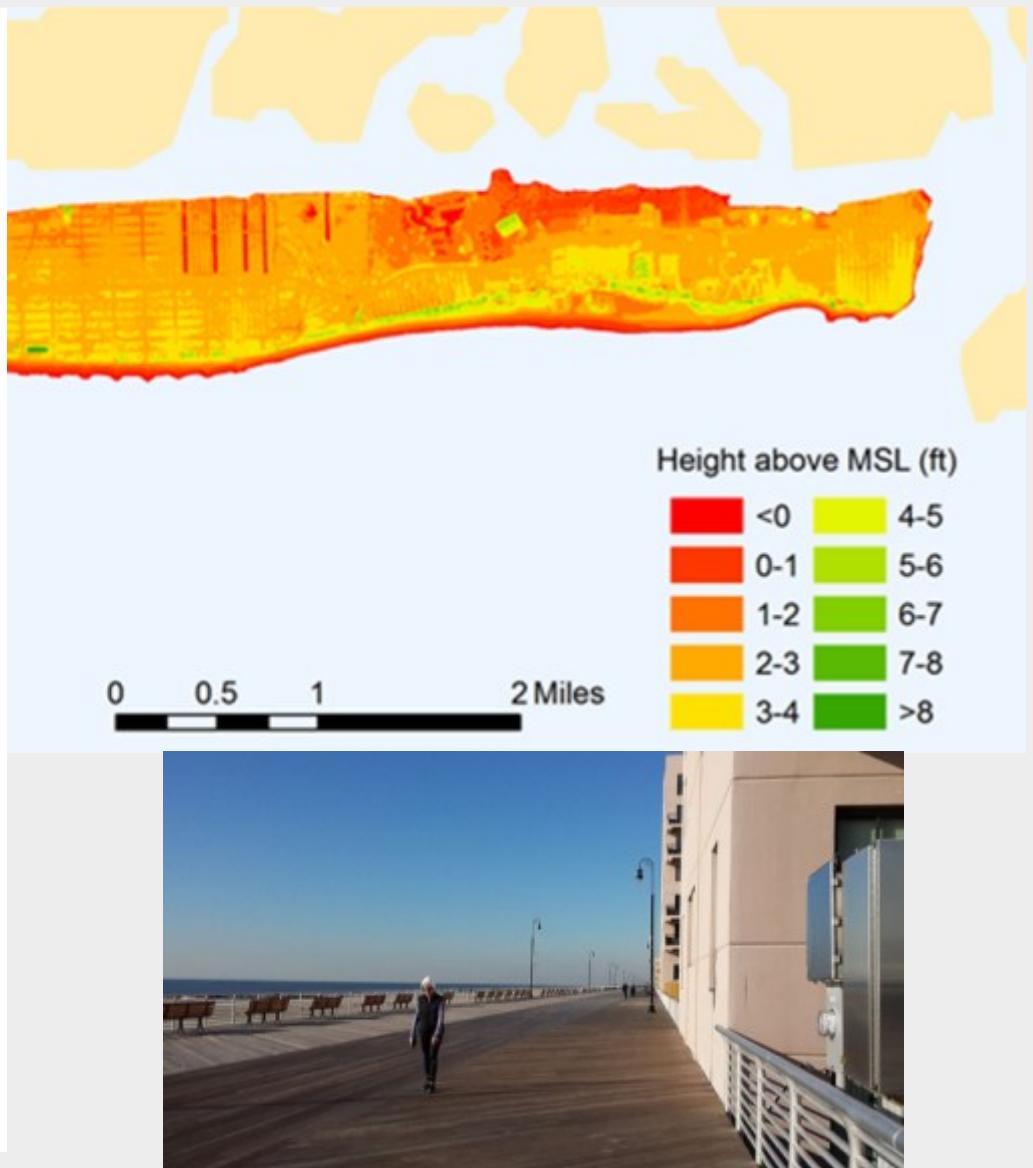
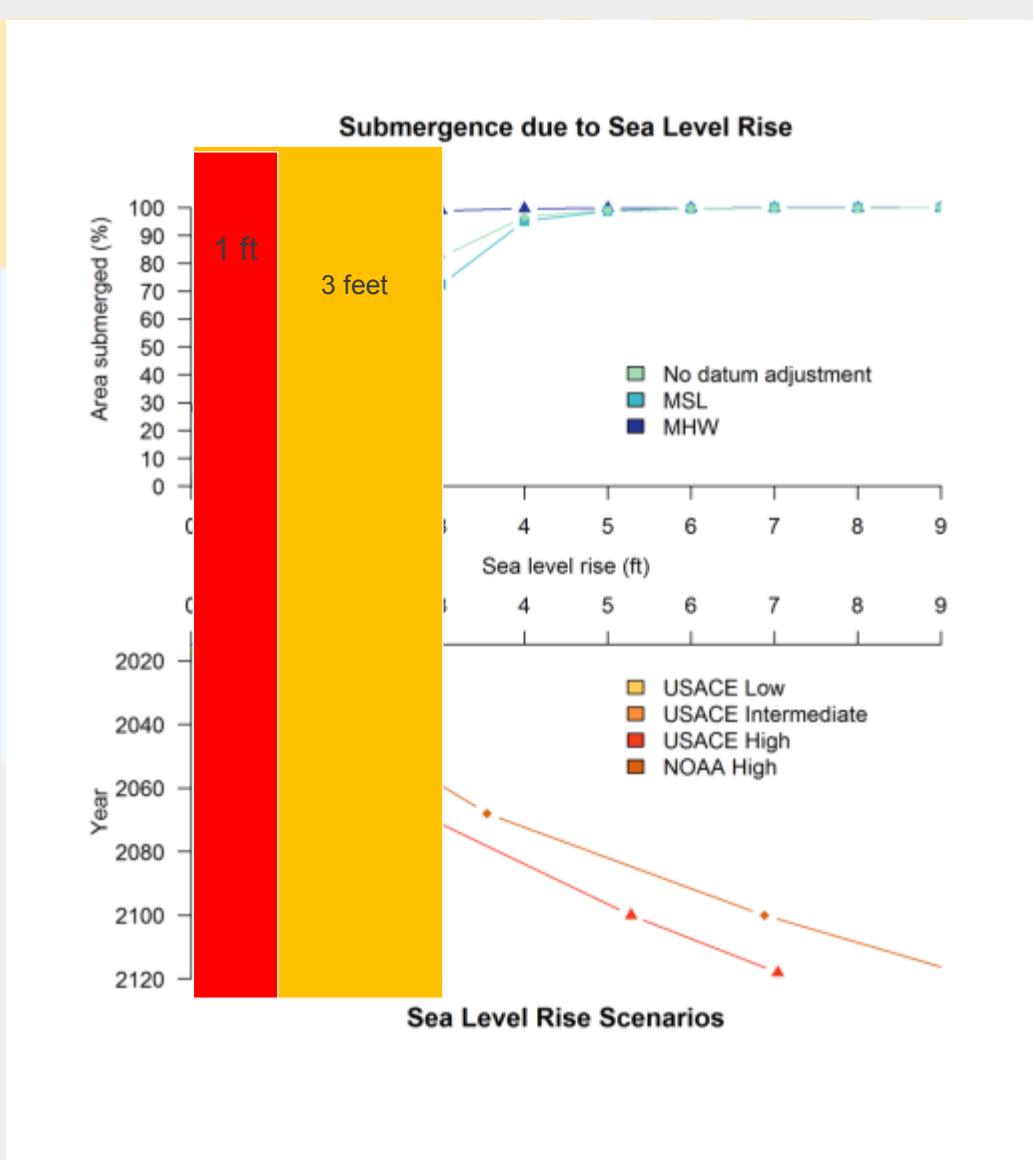
- beach replenishment on seaward face, and sediment bypassing around the jetties, has allowed the two halves to be maintained as coastal defences.
- encouraging the natural vegetation to continue to act as dune or marsh stabilisation is also a priority method of maintenance.
- restricting the development of human infrastructure or encouraging relocation of existing infrastructure would be beneficial if the barrier islands are to continue as an effective coastal defence for the mainland as sea levels rise.



Long Beach NY



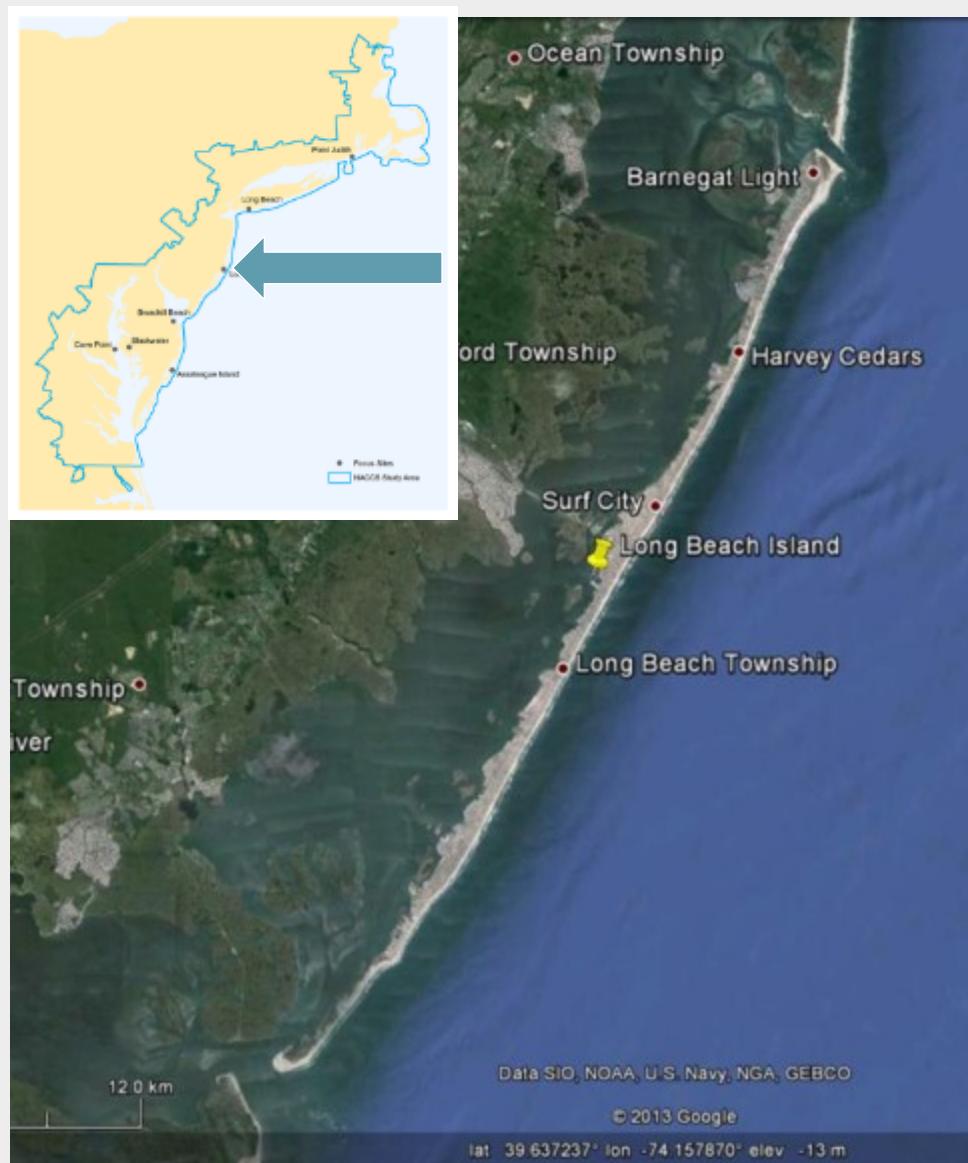
Long Beach, NY



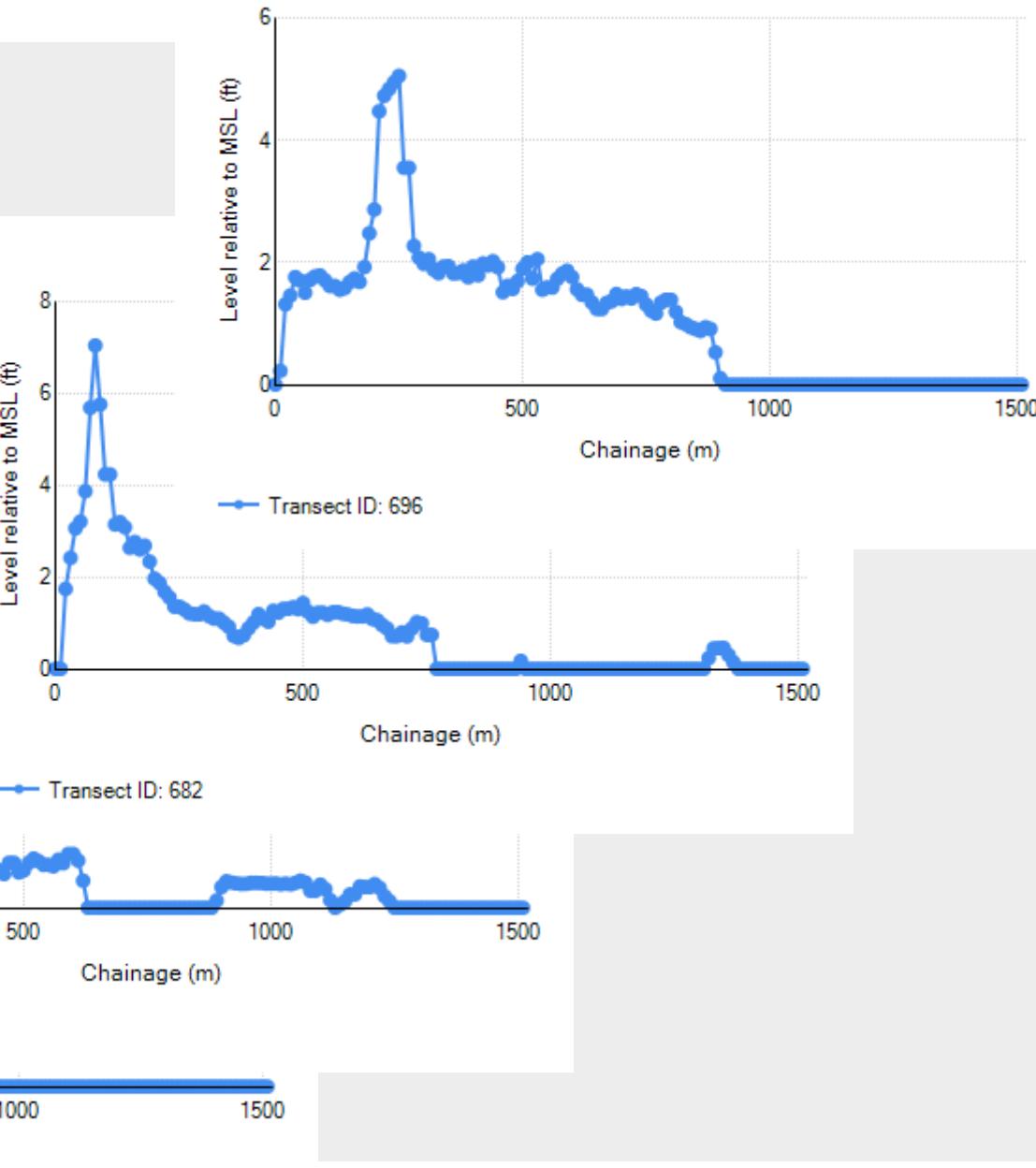
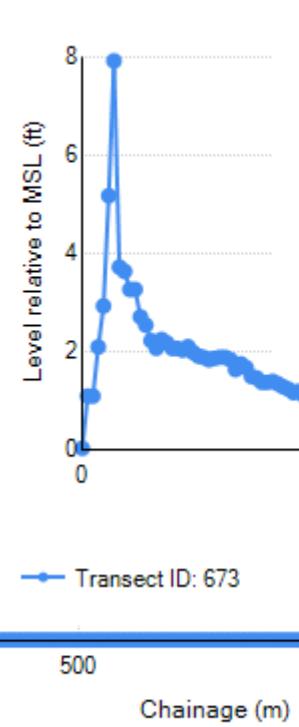
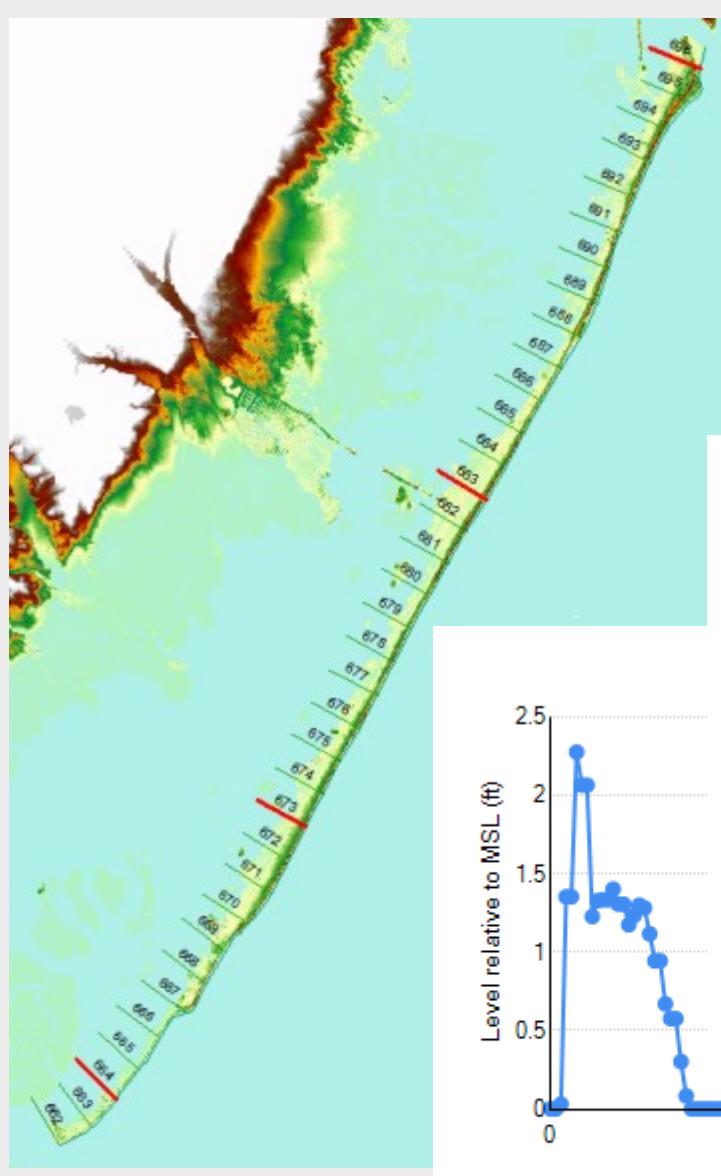


HR Wallingford
Working with water

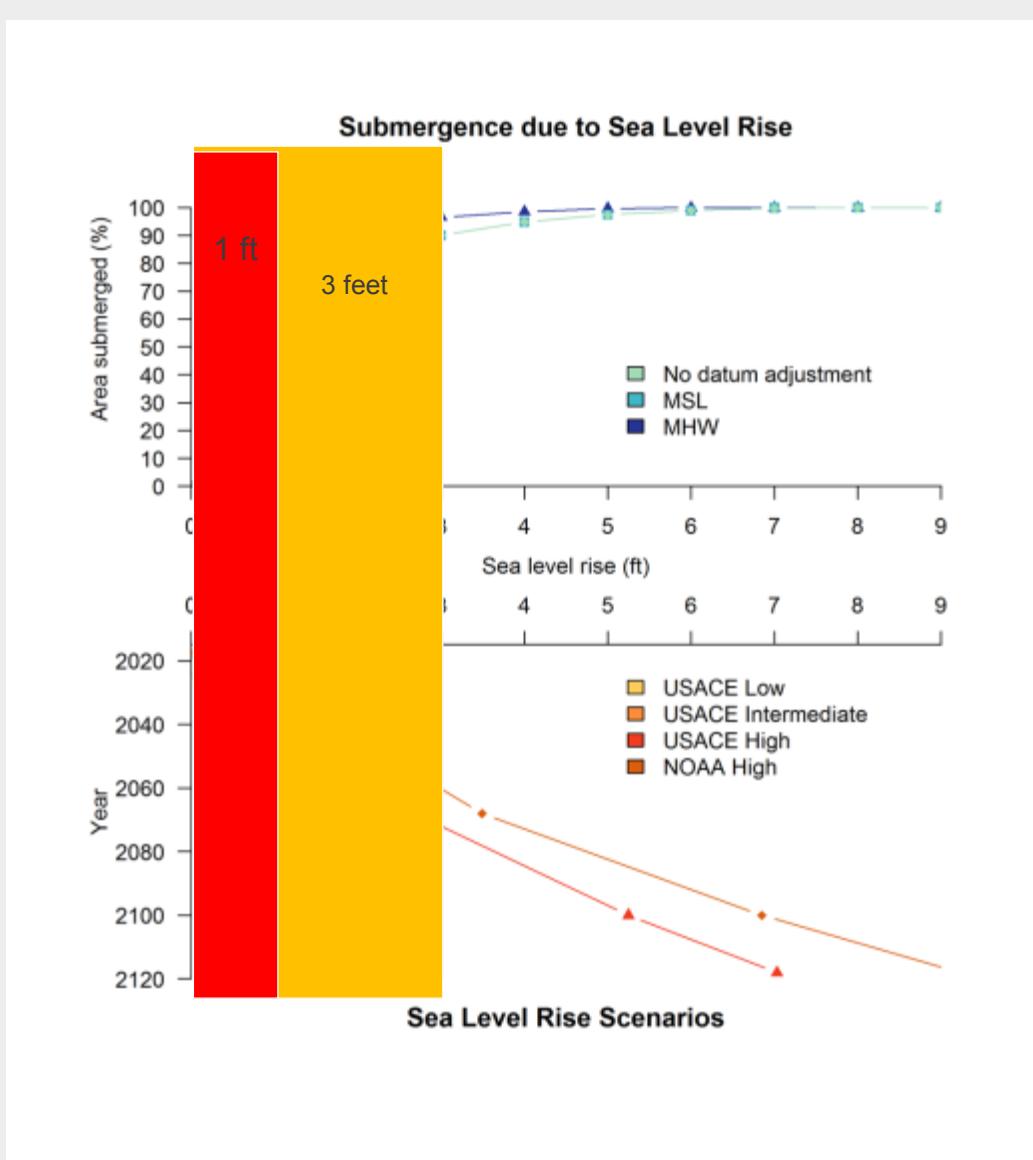
Long Beach Island, NJ



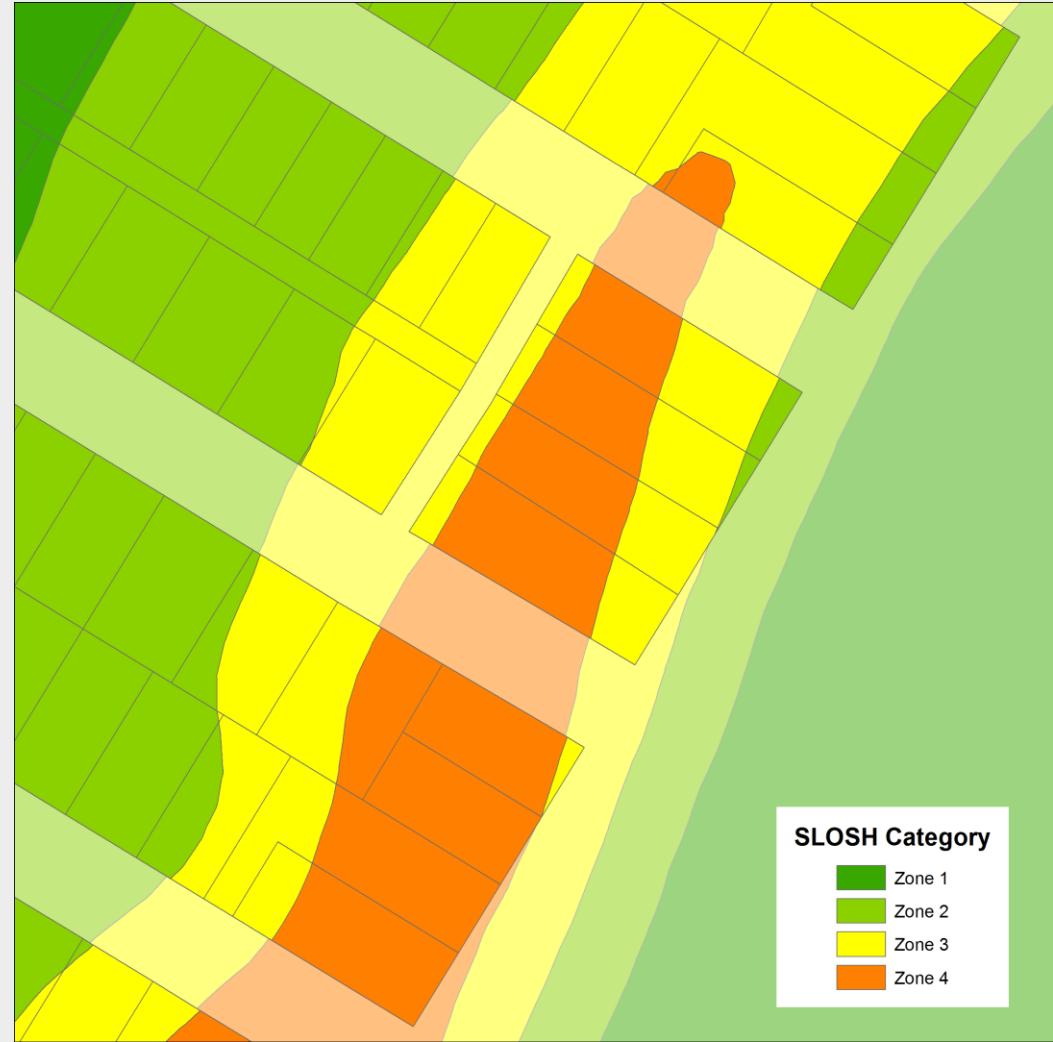
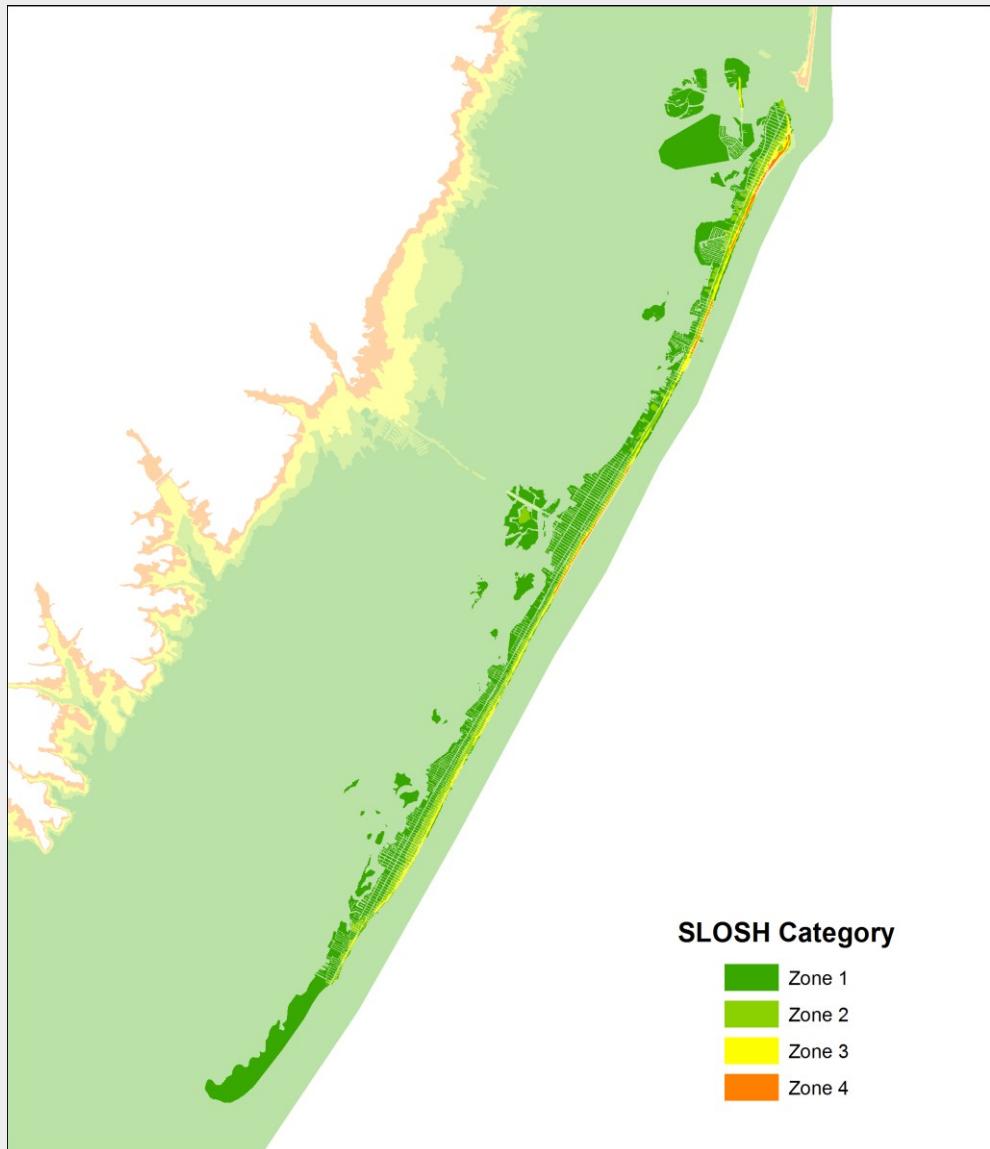
Long Beach Island, NJ – cross sections



Long Beach Island, New Jersey

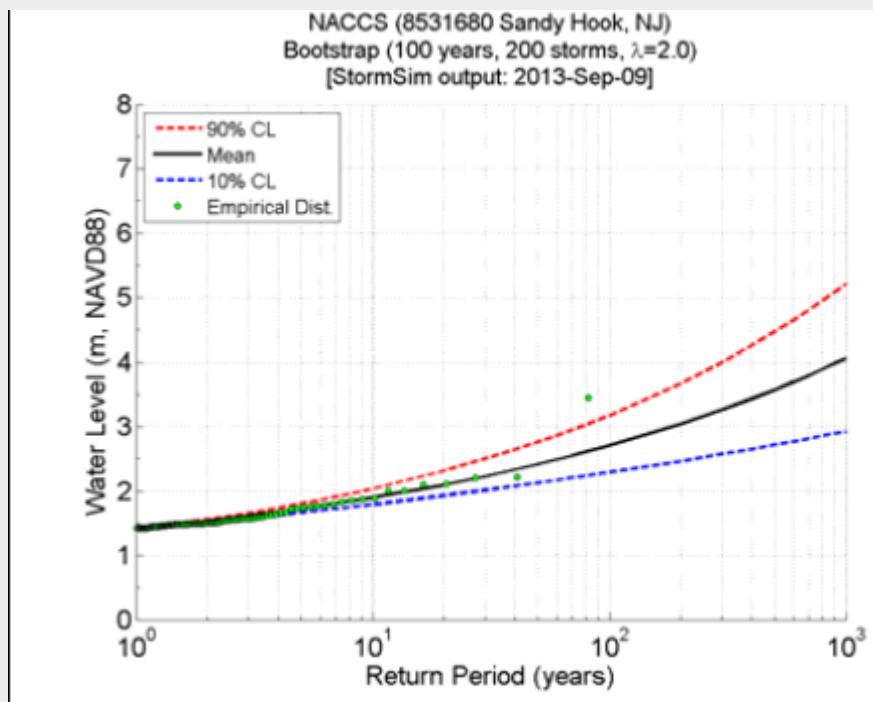


Long Beach Island NJ - SLOSH zones



Initial analysis SLOSH outputs Long Beach NJ

- a. Use of Saffir-Simpson scale to convert (approximately) storm categories to surge levels
- b. Approx return periods from ERDC StormSim analysis



Saffir–Simpson Hurricane Scale

Category	Wind speed mph (km/h)	Storm surge ft (m)
Five	≥156 (≥250)	>18 (>5.5)
Four	131–155 (210–249)	13–18 (4.0–5.5)
Three	111–130 (178–209)	9–12 (2.7–3.7)
Two	96–110 (154–177)	6–8 (1.8–2.4)
One	74–95 (119–153)	4–5 (1.2–1.5)

Initial analysis SLOSH outputs Long Beach NJ

Expected Annual Flooded Parcels

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	TOTAL	
Parcels	1041	300	59	3	4	1407	7.0%

Expected Annual Flooded Area

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	TOTAL	
Area (sq m)	1372230	347574	67469	3102	4654	1795030	7.7%
Area (sq ft)	14770564	3741261	726235	33395	50092	19321547	7.7%

c. Expected annual flooded area /no of parcels =
 7% of total for present day conditions

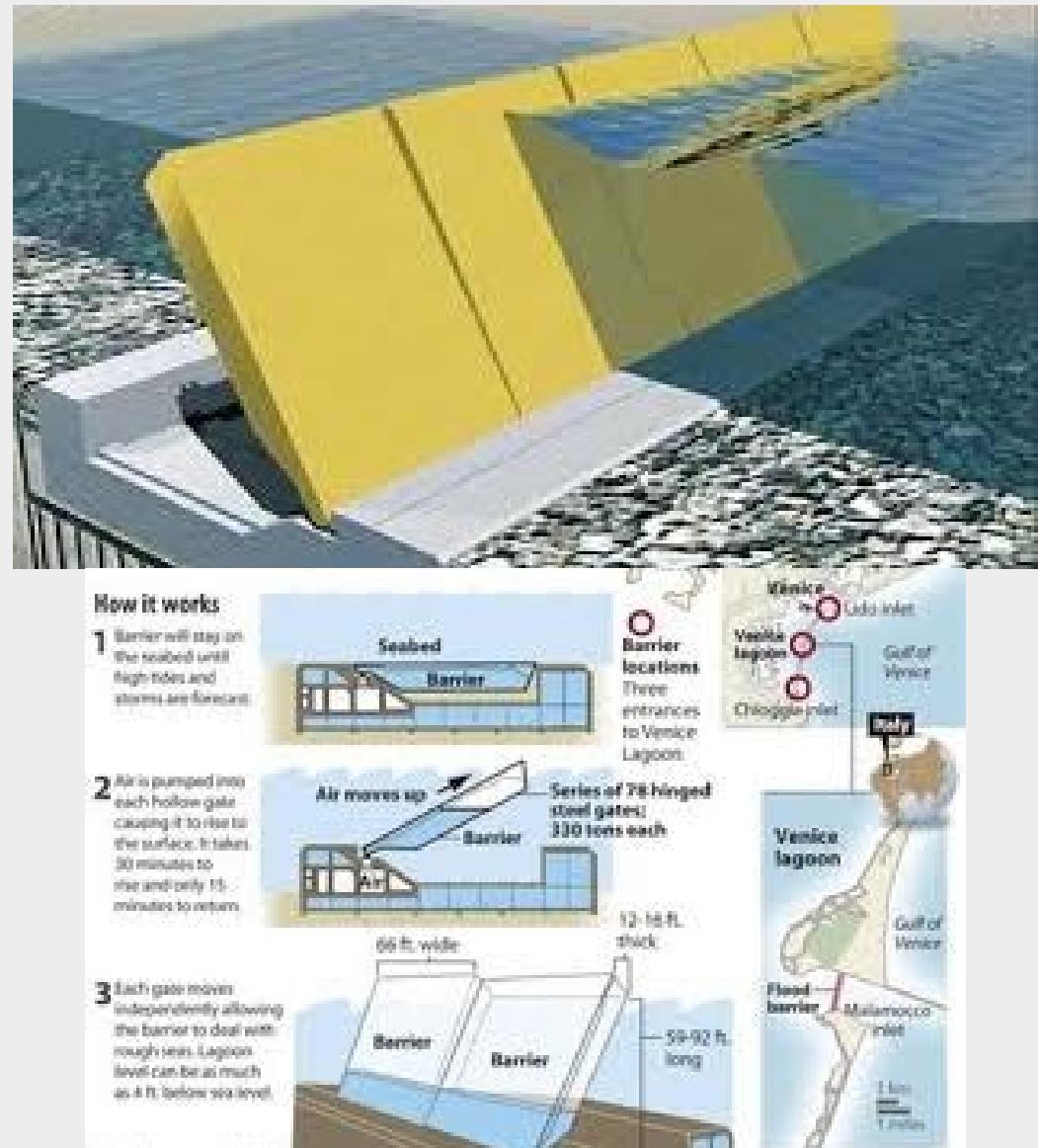
Barrier Island measures

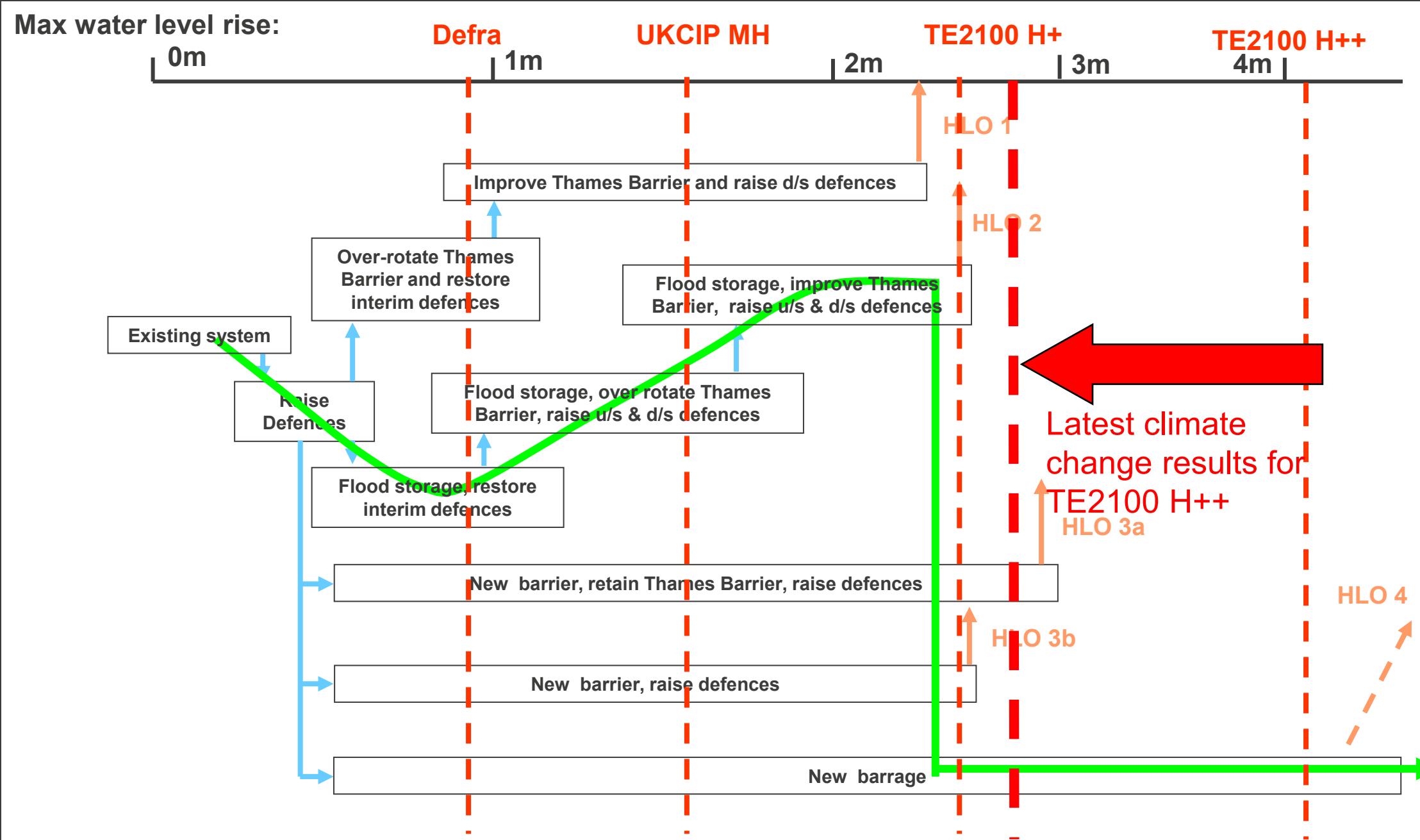
'Pathway' measures

- Atlantic freeboard: Maintain beach schemes (need for backing walls?)
- Backshore of islands – solution of protecting by flood walls or levees
- Back bay frontage – dunes and walls
- Alternative: protect both backshore of islands and back bay using Venice style barriers between barrier islands

'Receptor' measures

- Building elevation - short term effectiveness due to submergence of access
- Others??





TE 2100 final plan: combination of approaches

Decision pathways for inhabited barrier island

Seaward
shoreline
protection

Landward
/back-bay
shoreline
protection

Non-
structural
measures

Sea level rise

Beach recharge

Add groins, detached breakwaters, sills

Add levees, revetments or floodwalls

Unprotected shoreline

Add levees or floodwalls

Wave protect flood walls by natural features

Surge barriers

Flood warning and occasional evacuation

Flood-proofing properties

Elevating properties

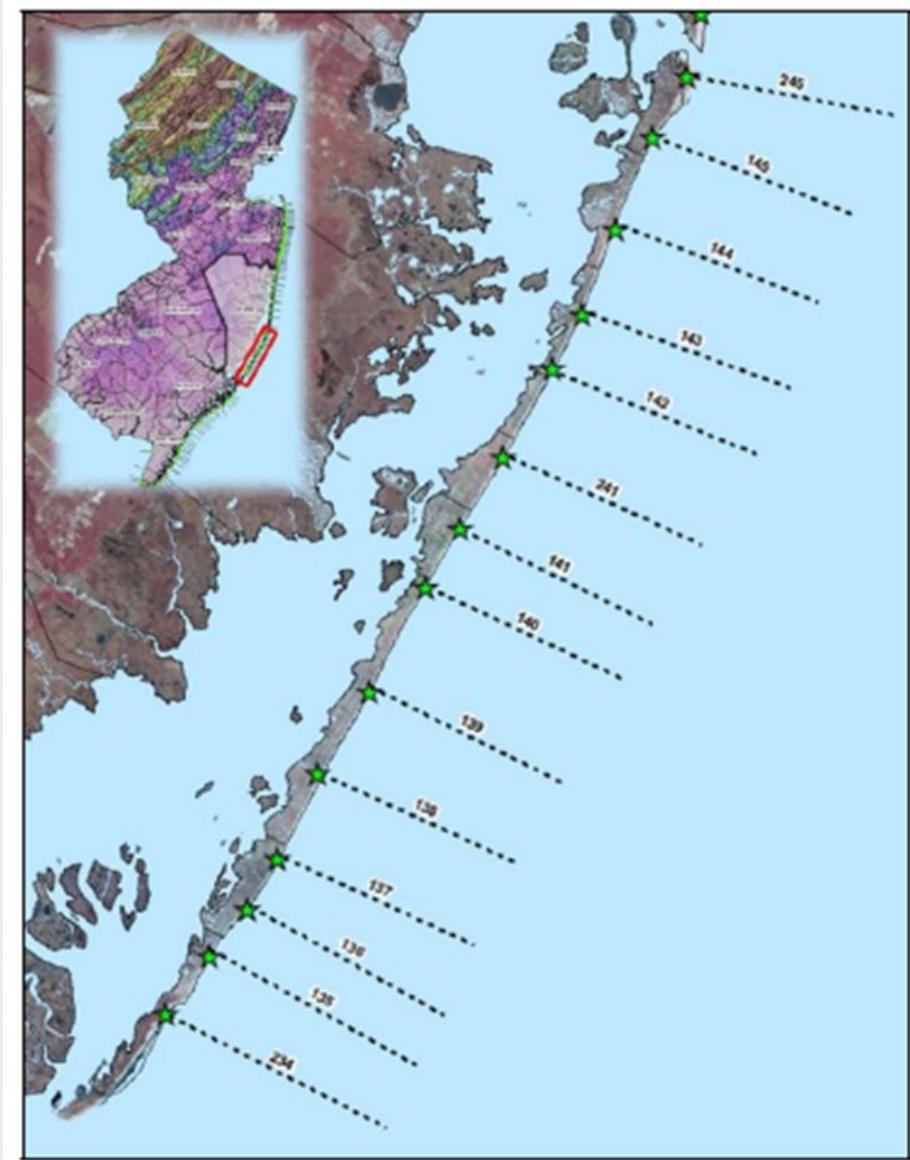
Community relocation

Morphological issues on Atlantic freeboard (approach modified over last month)

- Decision to focus (given limited time) primarily on cross-shore response rather than long shore response
- Long Island NJ focus – best data available

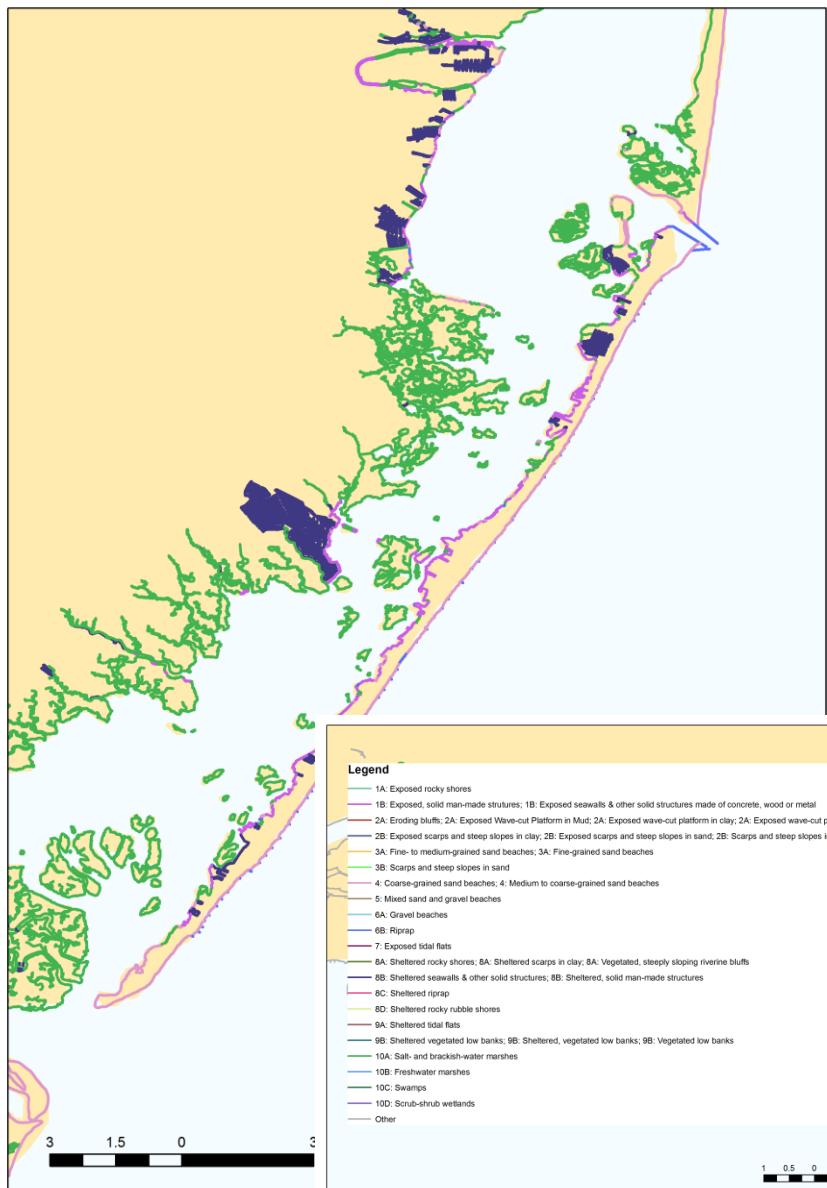
Steps to evaluate dune-beach systems

1. Overview existing morphological data using review of literature and results of comprehensive studies.





Geomorphological review and characterisation



- Protection Areas
- Beaches
- Backshore
- Offshore Transport Rates
- Erosion and Accretion
- Sediment Budget
- Flood Risk Areas
- Engineering Works
- Historical Data
- Response to Extreme Events

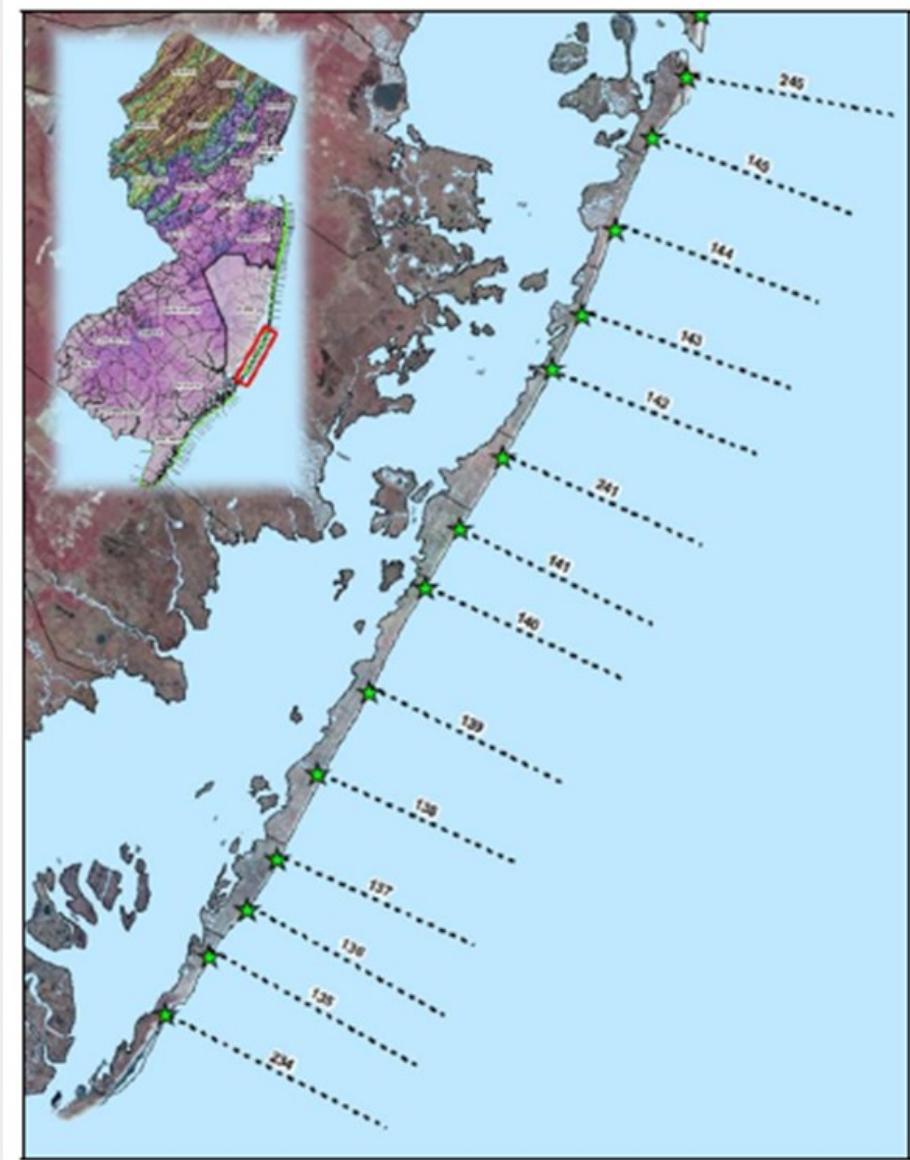


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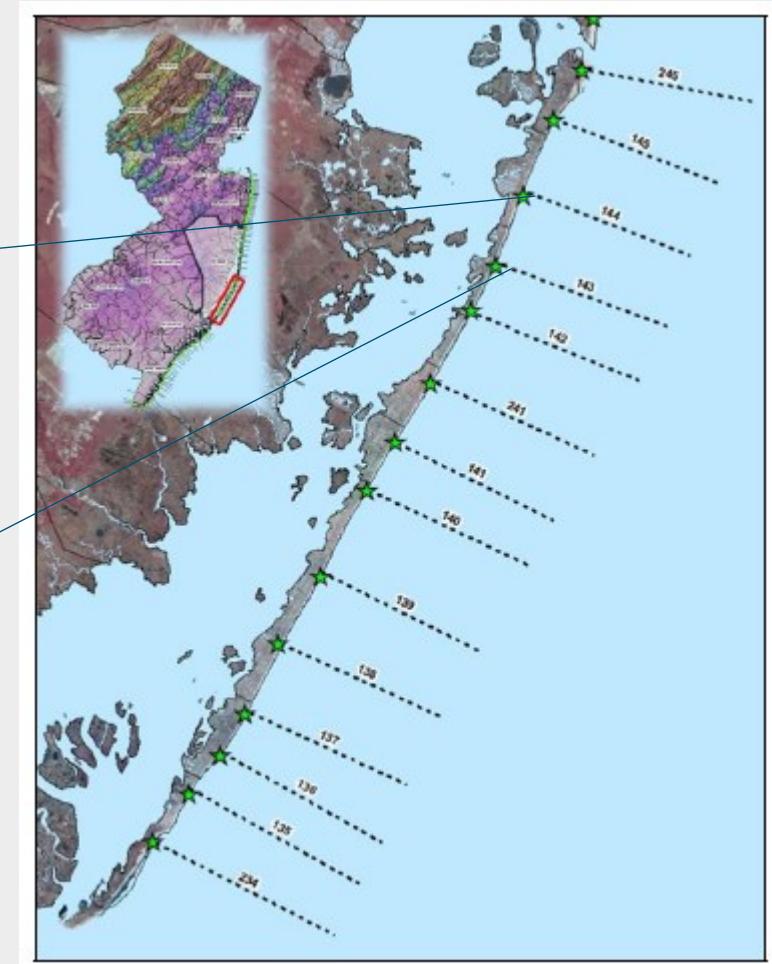
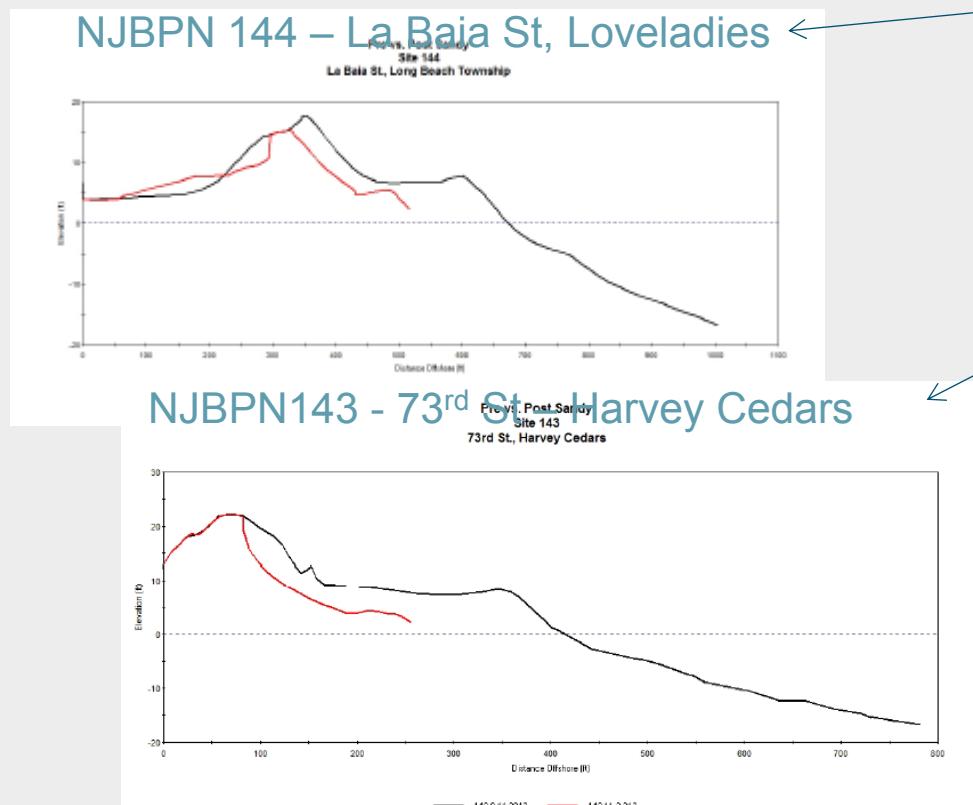
Steps to evaluate dune-beach systems

1. Overview existing morphological data using review of literature and results of comprehensive studies
2. Validate a dune erosion rule using Stockton CMC measured profiles.



Methodology

- Stockton CRC (2013) survey data on Long Beach Island (NJ) on the NJ Beach Profile Network
 - Fall 2012
 - November 2012



Utilise data in order to validate dune erosion rule by comparing Stockton CMC profiles during

- normal SL and elevated SL
- during Hurricane Sandy

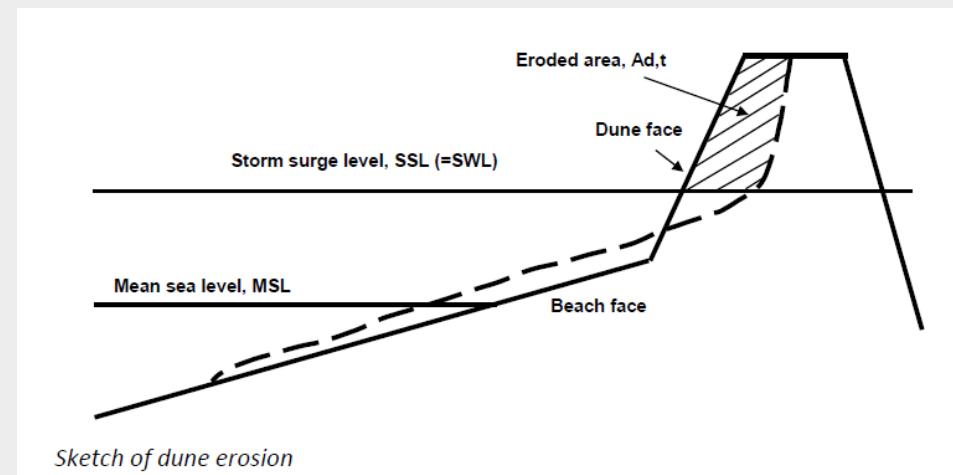
Various dune erosion rules available

DUNERULE model (van Rijn, 2013):

Based on sensitivity tests to the CROSMOR model

It gives Dune erosion area (A) above storm surge level (S) as a function of peak period (T), offshore significant wave height (H), median bed material diameter (d₅₀), slope gradient ($\tan\beta$), offshore wave incidence angle (Θ)

$$A_{d,t=5} = A_{d,\text{ref}} \left(d_{50,\text{ref}} / d_{50} \right)^{\alpha_1} \left(S / S_{\text{ref}} \right)^{\alpha_2} \left(H_{s,o} / H_{s,o,\text{ref}} \right)^{\alpha_3} \left(T_p / T_{p,\text{ref}} \right)^{\alpha_4} \left(\tan\beta / \tan\beta_{\text{ref}} \right)^{\alpha_5} \left(1 + \theta_o / 100 \right)^{\alpha_6}$$

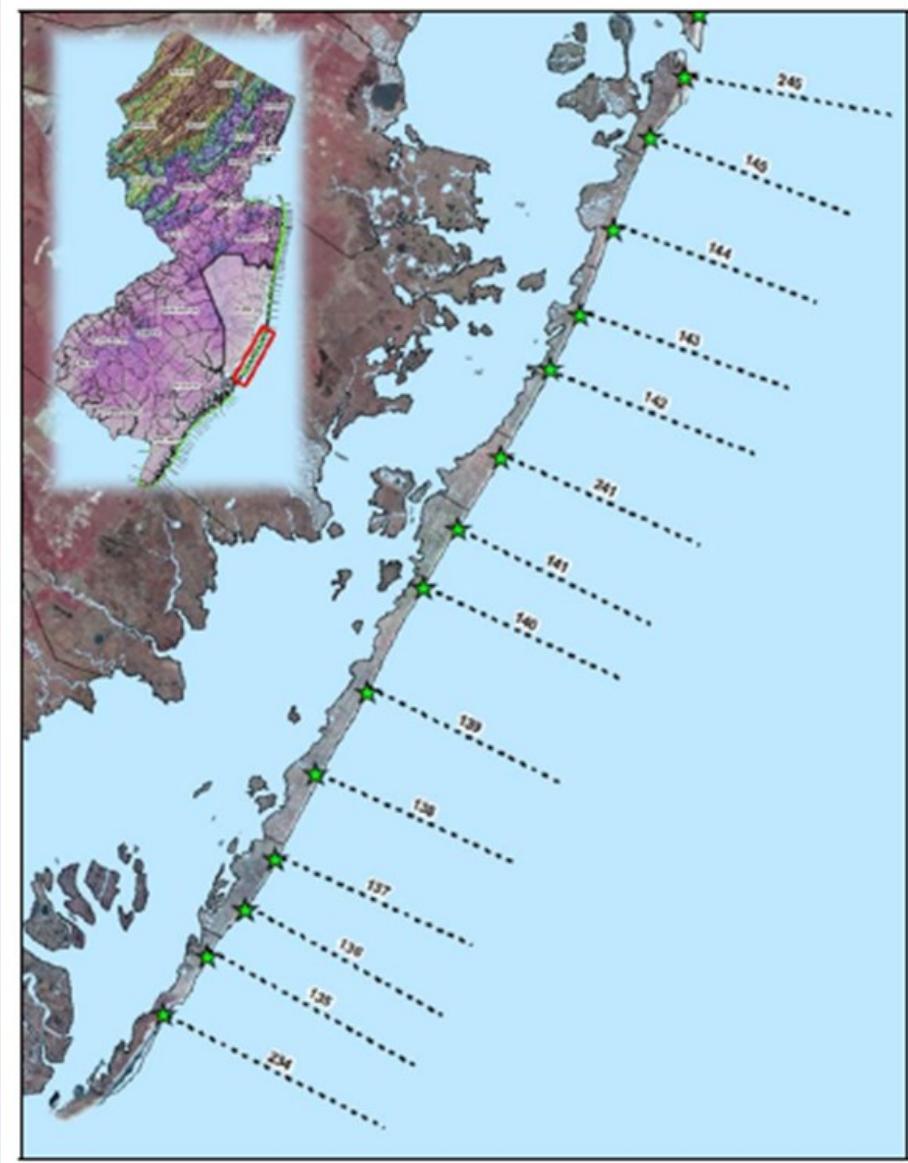


Morphological issues on Atlantic freeboard (approach modified over last month)

- Decision to focus (given limited time) primarily on cross-shore response rather than long shore response
- Long Island NJ focus – best data available

Steps to evaluate dune-beach systems

1. Overview existing morphological data using review of literature and results of comprehensive studies
2. Validate a dune erosion rule using Stockton CMC measured profiles.
3. Predict dune erosion for different sea level rise scenarios
4. Calculate overtopping rates for different sea level rise scenarios to input into inundation models



Evaluation of effect of measures

Propose to look at the following policy options for both beach-dune systems (following general approach adopted during Thames Estuary 2100 study) and assess the following alternative policies

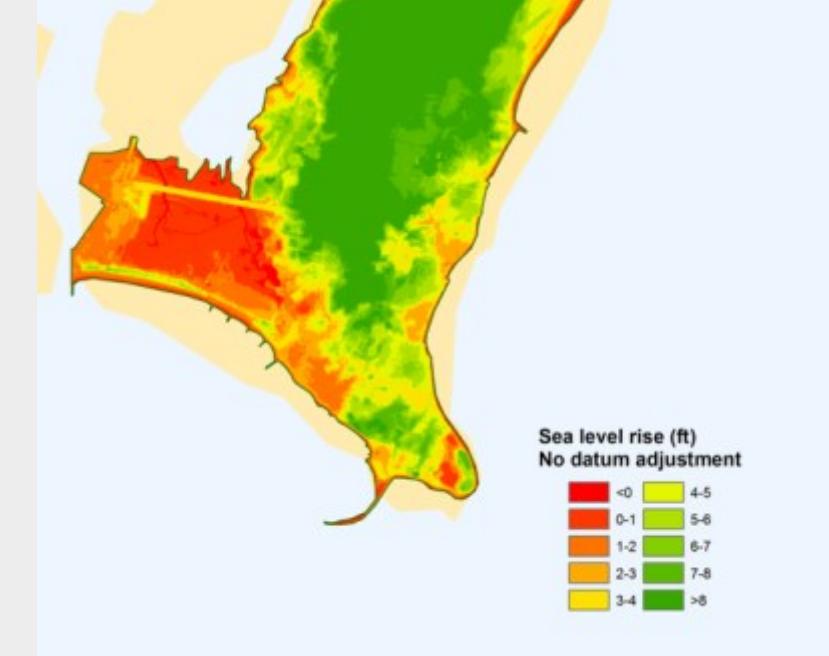
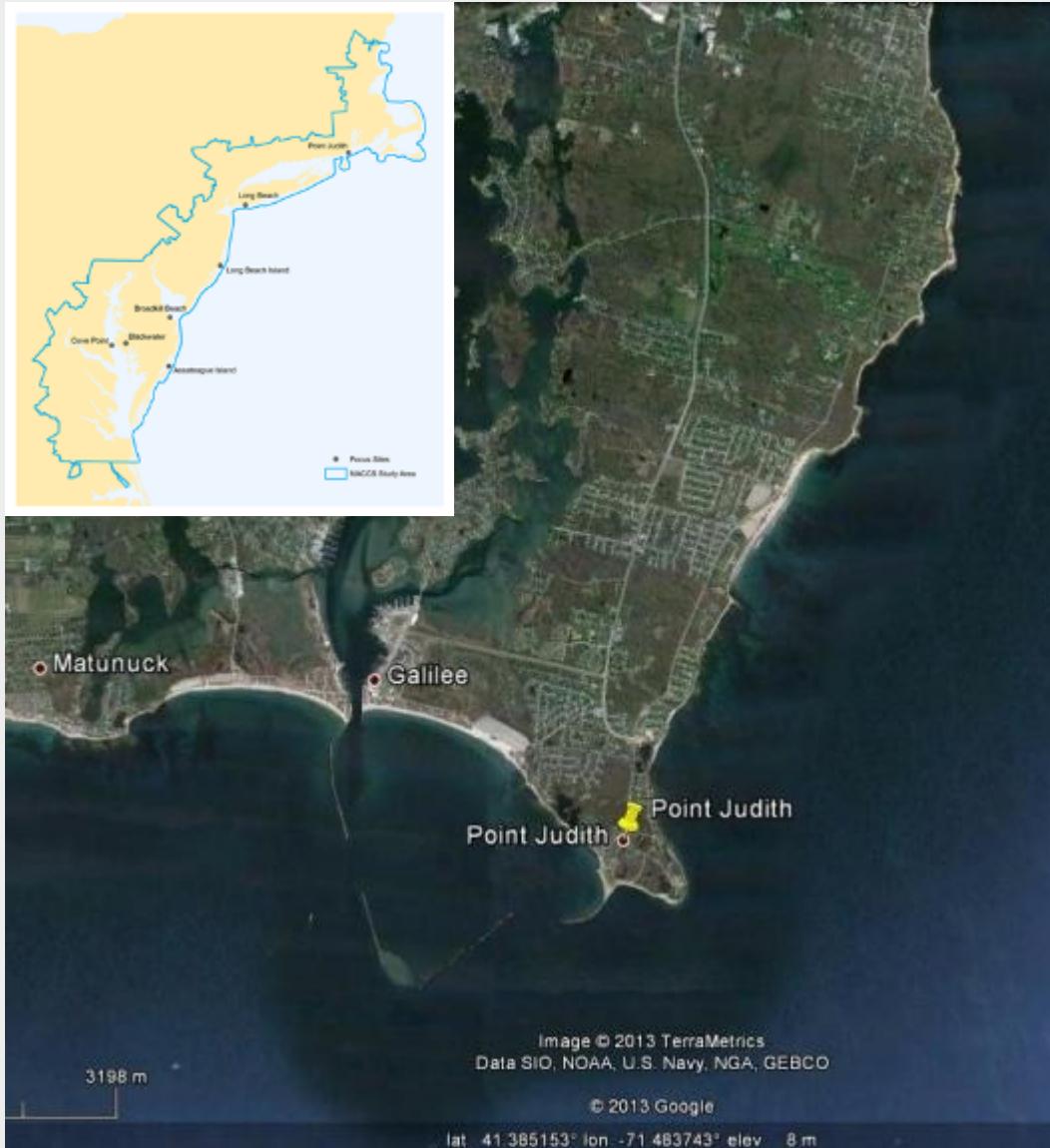
- P1 – walk away
- P3 – maintain defences at 2014 crest level and structural condition
- P4 – raise defences in line with sea level change and maintain condition

Whether defences breach as well as overtop will depend on condition

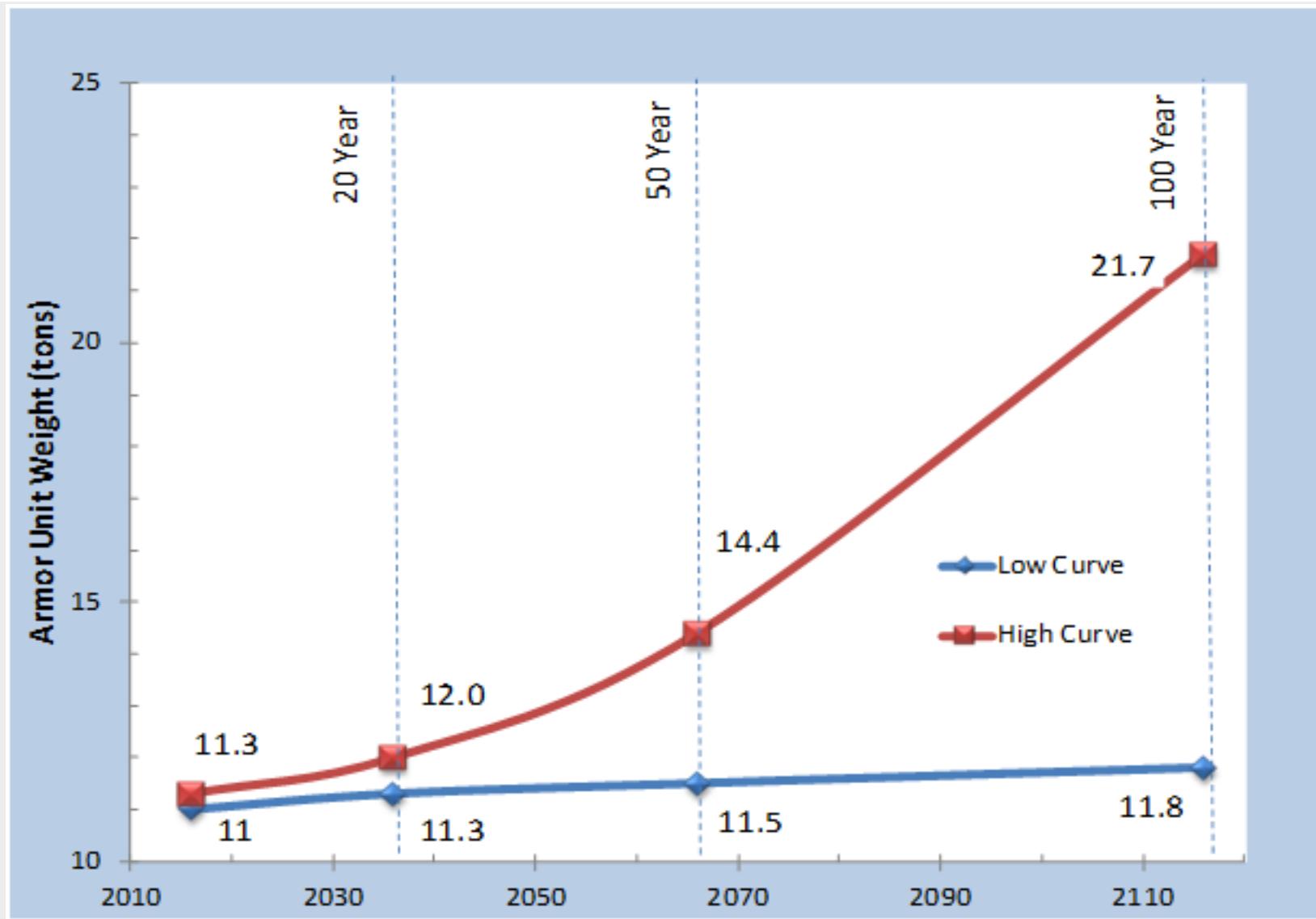
For each case, examine impact of policy options via:

- Submergence studies for barrier islands and other low-lying areas (normal conditions)
- Assessments of flood risk in populated areas by examining a range of extreme conditions

Point Judith, RI

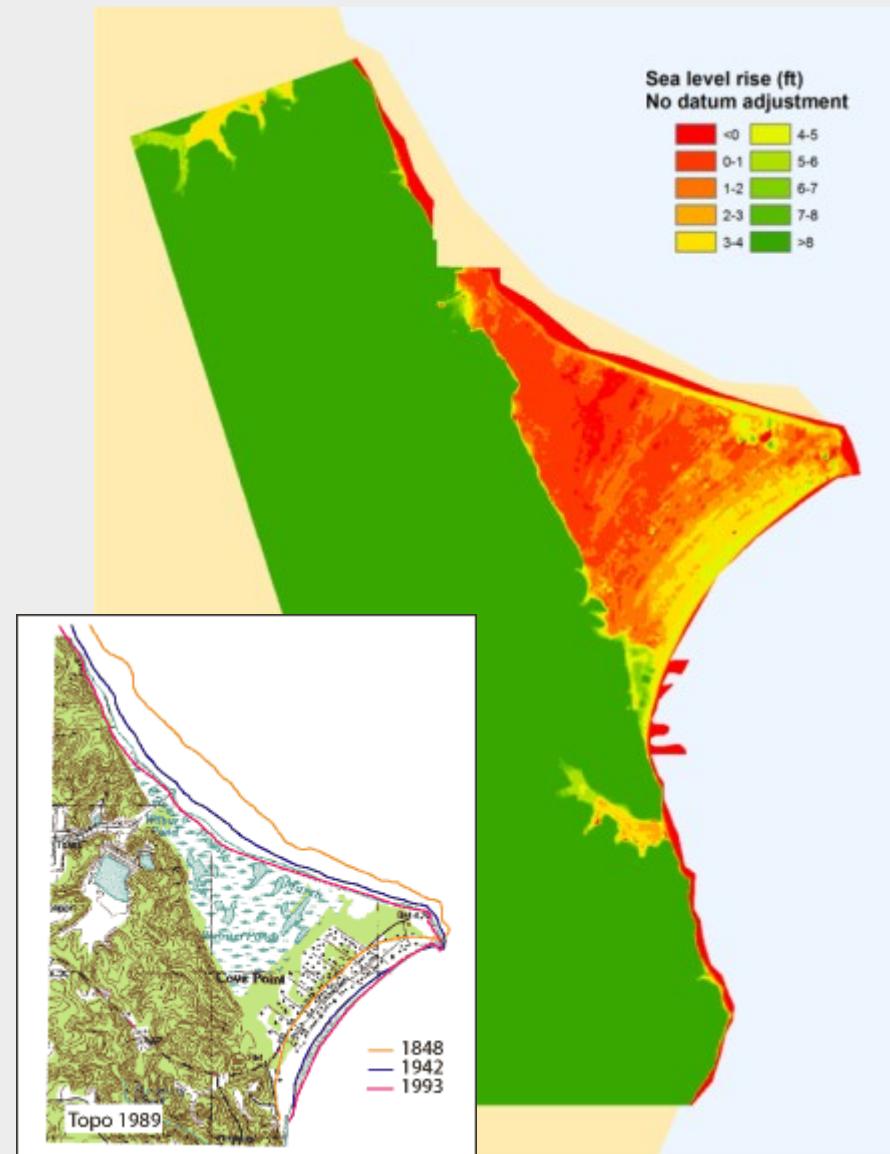
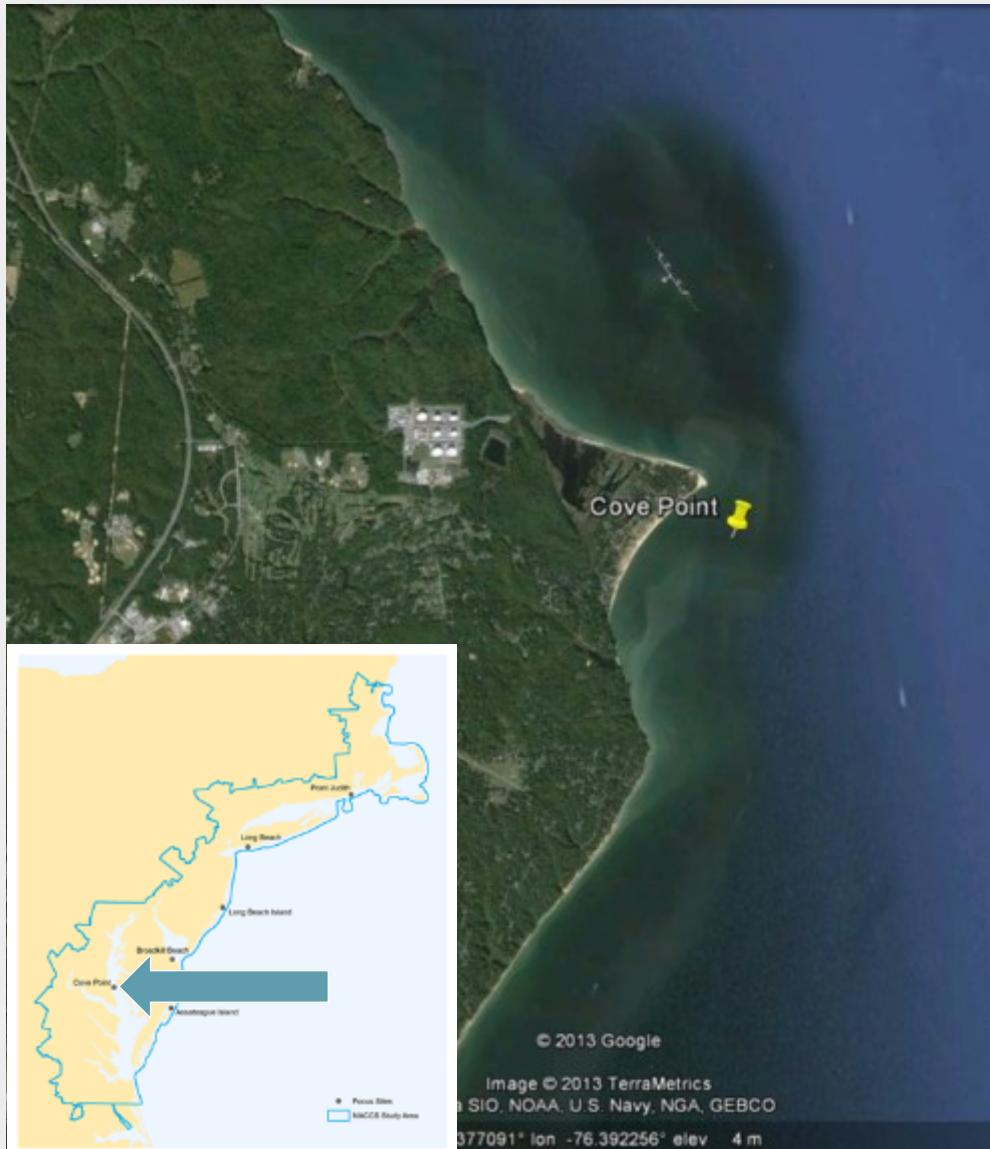


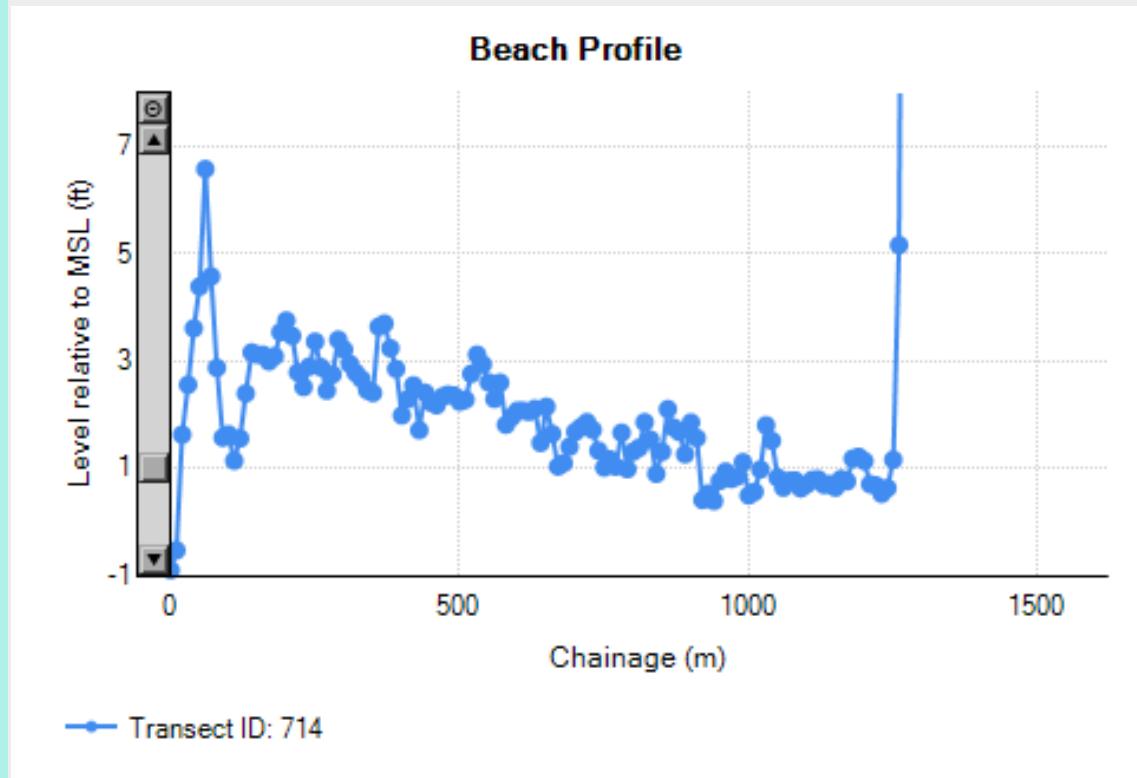
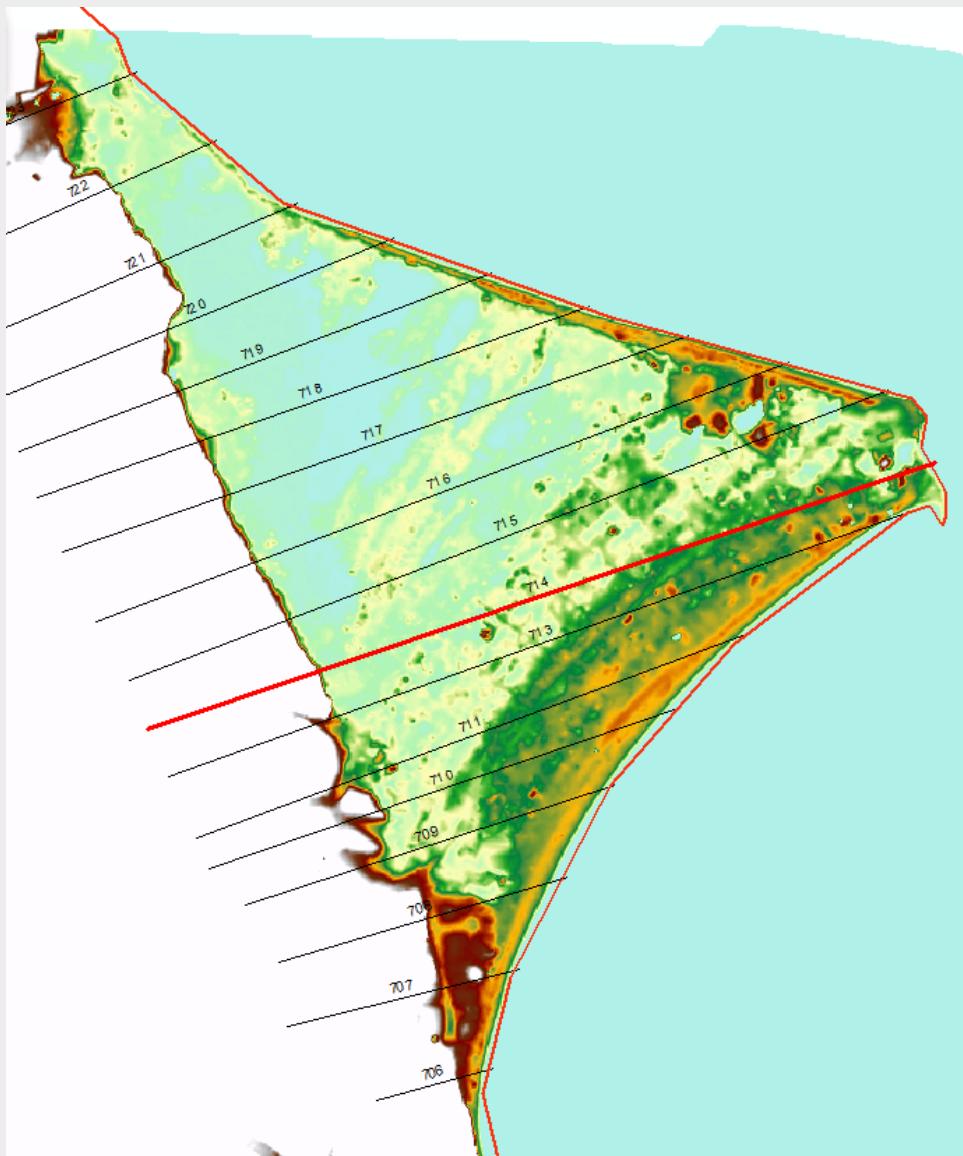
Sensitivity of seaward design armour for rubble-mound structure



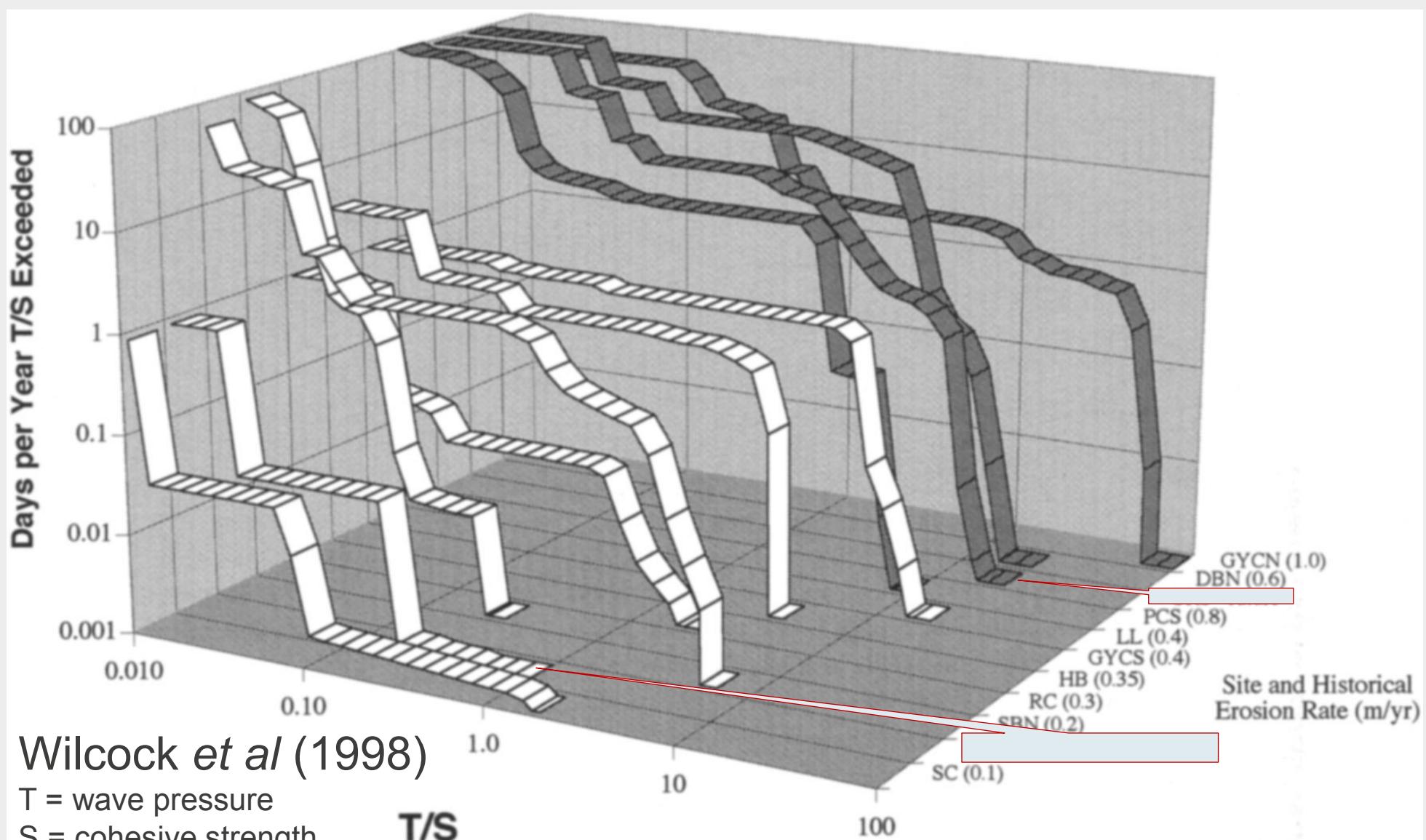
Source: John Headland, Moffatt & Nichol

Cove Point, MD





Recession of Calvert Cliffs near Cove Point

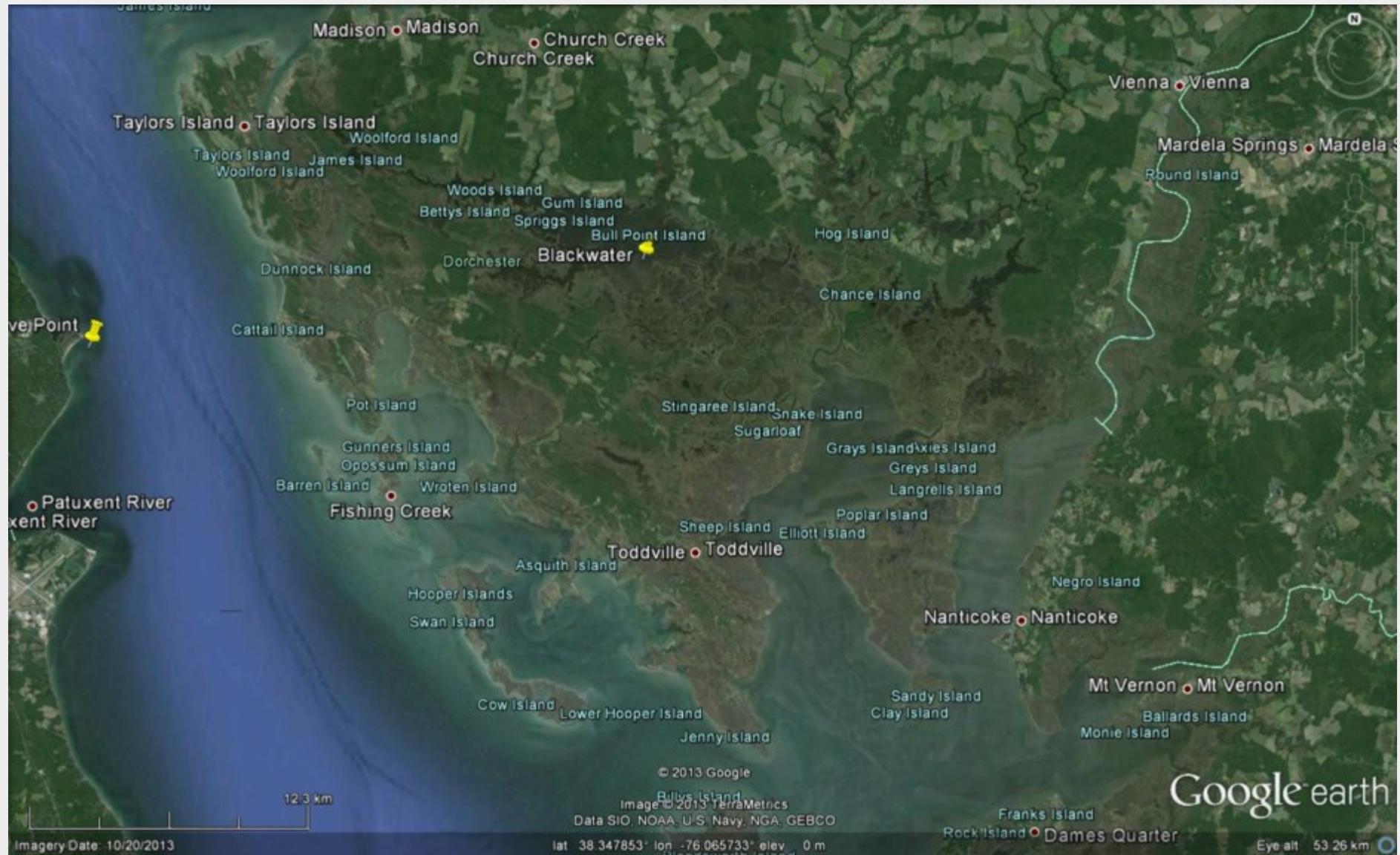


Wider environment of Chesapeake Bay

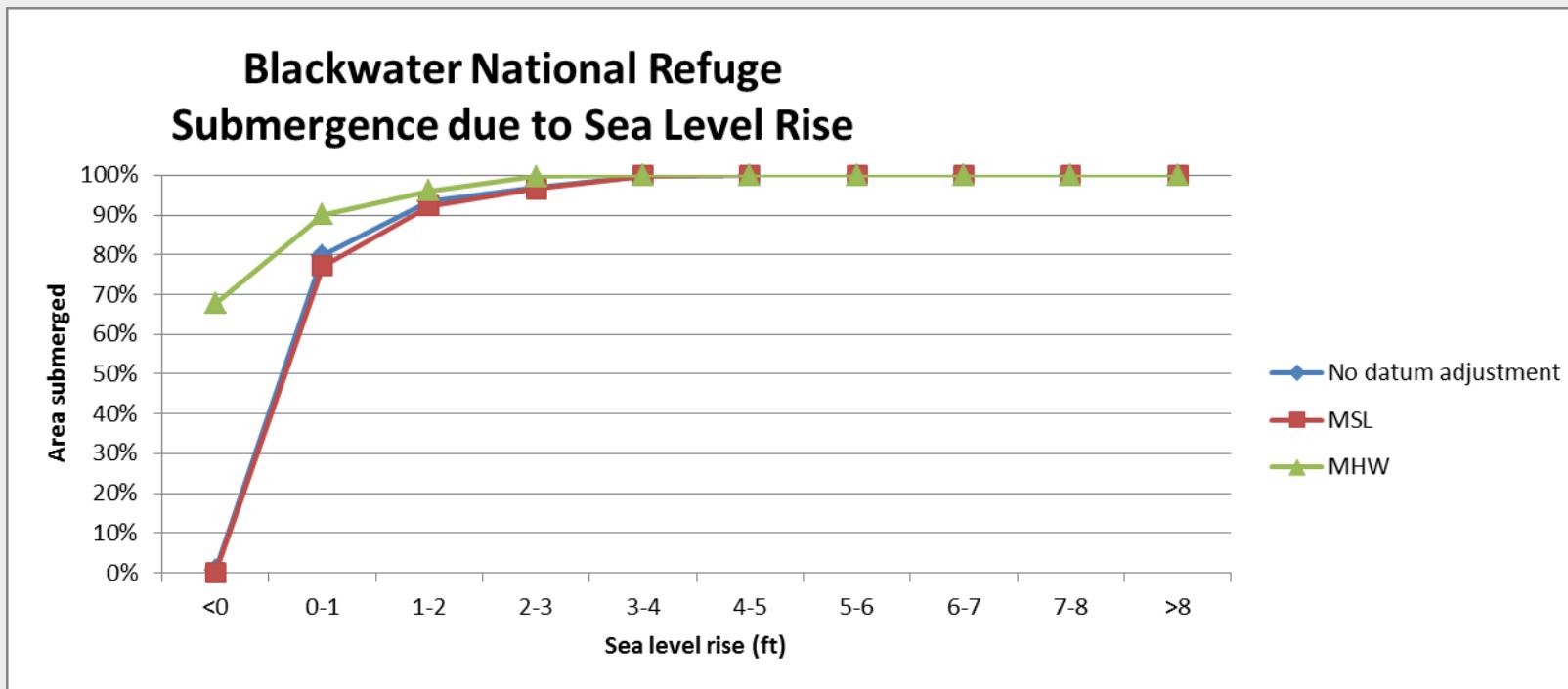




Blackwater National Nature Reserve



Inundation extensive with very little increase in sea level



The wider area is gradually being lost as well

Straight cut drainage ditches as example of extensive anthropogenic modification



Blackwater National Nature Reserve - measures

- Existing study of potential measures fairly comprehensive
- Encouraging migration of wetlands most effective, but barriers to such require identification and addressing
- Trickle charging with sediment might be useful, rather than direct placement?
- Reshaping of straight cuts
 - Use a more dendritic drainage pattern rather than infilling, or leaving as is
 - Slowing the straight cut drainage erosion by strategic brushwood check dams
- Ensuring propagule supply and distribution rather than a deliberate planting scheme



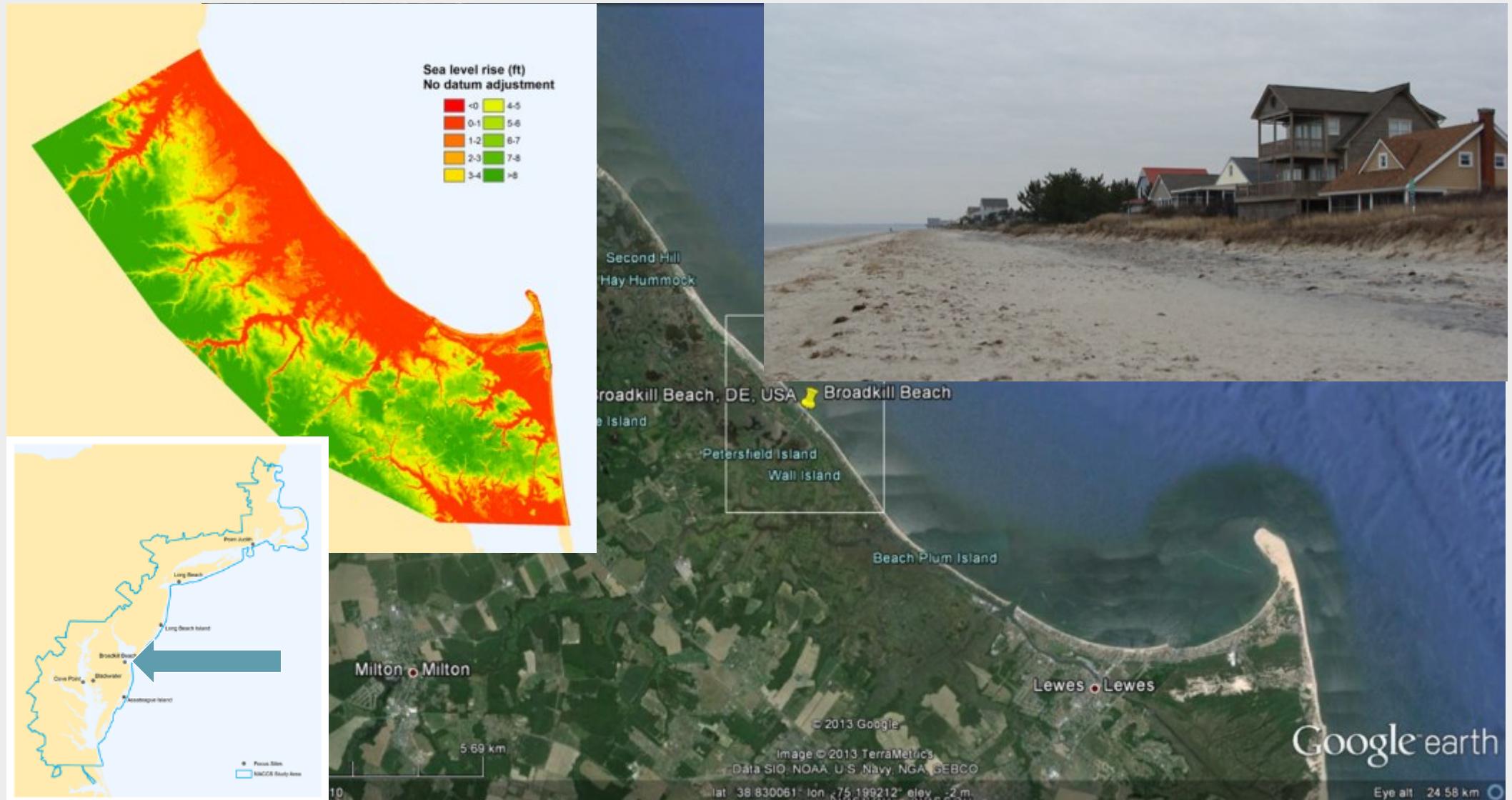
Engineered dendritic ditches in managed realignment site, UK

Trickle-charging at Stour-Orwell estuary UK

- Marsh erosion and loss of extent through coastal squeeze.
- Trickle charging using sediments from navigational dredgings.
- Trickle charging 'tuned'
 - to the location
 - to reduce siltation in undesirable areas and
 - to optimise the flow of sediment by reducing the speed of discharge into the water column.
- Monitoring conclusions so far:
 - few areas of erosion
 - more accretion areas
 - trickle charging potentially useful

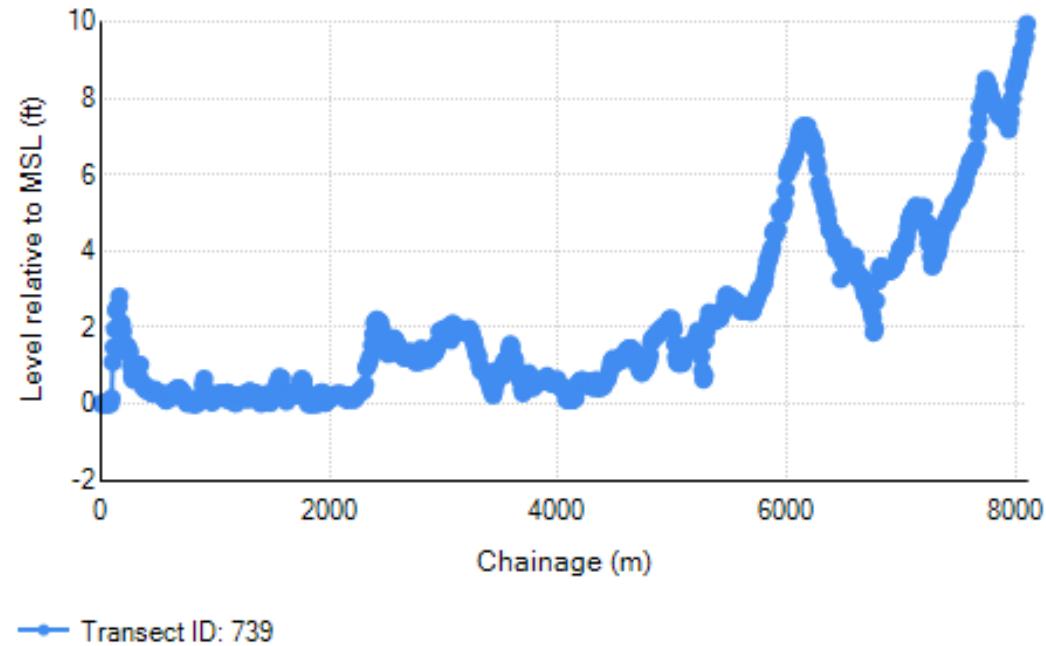
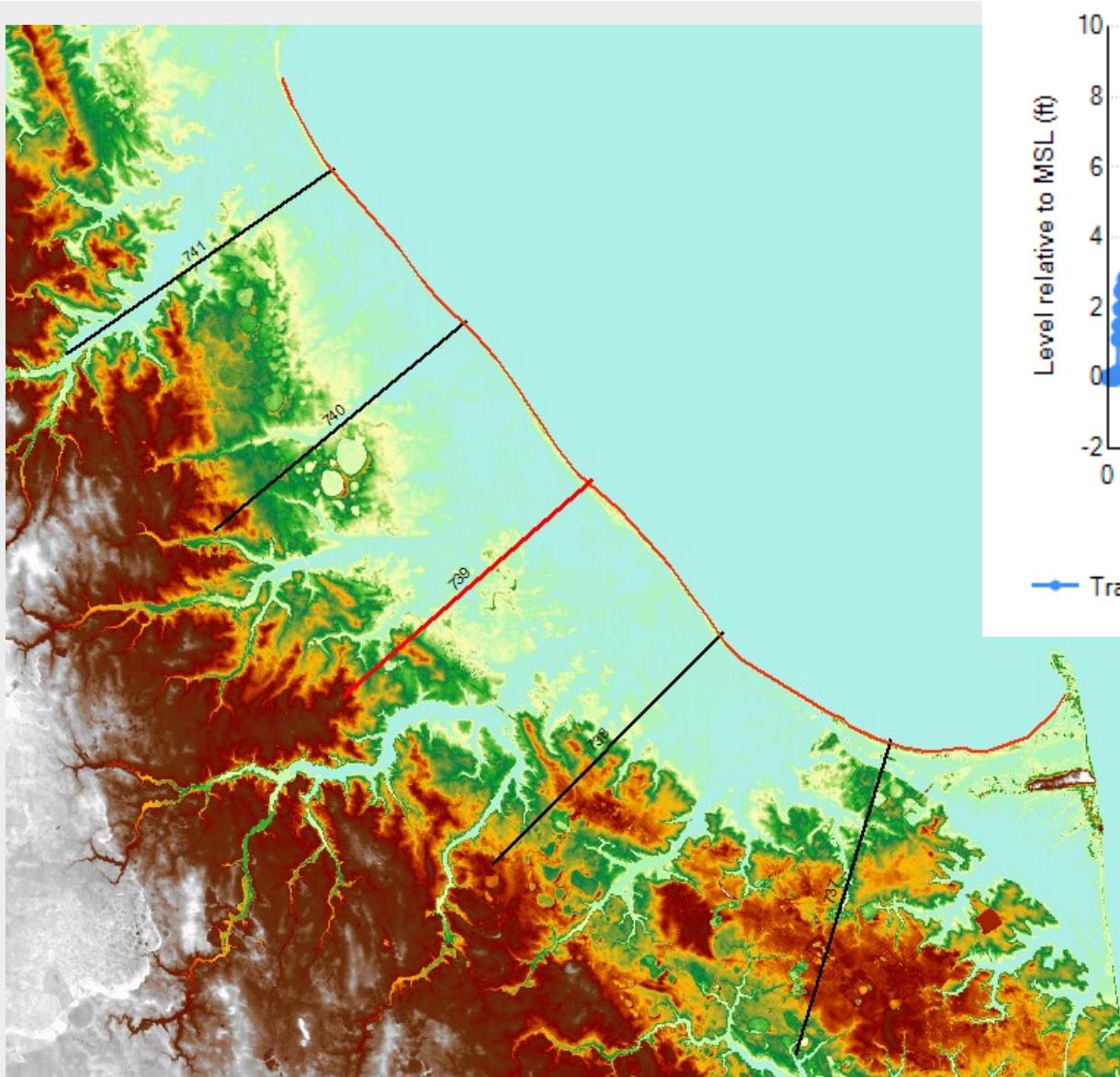


Broadkill Beach, DE



Broadkill Beach

Beach Profile



Similarities to barrier islands

- Narrow strip of properties protected by beach nourishment.
- No protection of 'back' side which is floodable due to tidal river and marsh areas behind

Similarities to Blackwater National Nature reserve

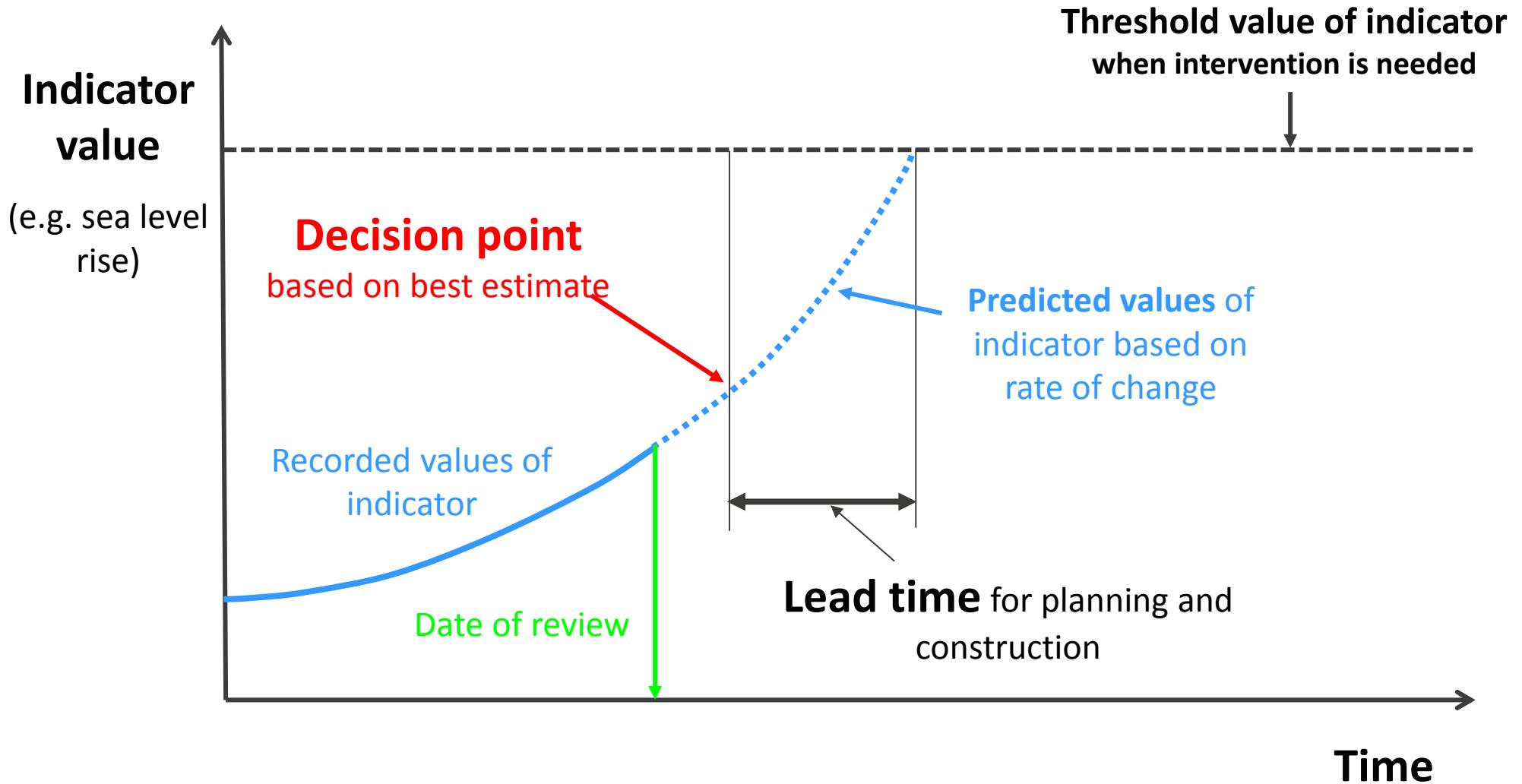
- Low lying marsh areas being progressively drowned by sea level rise
- Marsh areas may well not accrete due to (a) insufficient sediment and (b) regular land drainage pattern

Emerging uses of more severe SLC scenarios

The more severe SLC scenarios are (potentially) controversial in USA. However they can be useful:

1. In defining the extent of the project area
2. In representing (through the SLR rate curve) the earliest by which a problem may need to be addressed (including lead times)
 - e.g. tipping point in barrier island submergence

Tipping points: thresholds, lead times and decision points



Source: United Kingdom TE 2100

Emerging uses of more severe SLC scenarios

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1. In defining the extent of the project area
2. In representing (through the SLR rate curve) the earliest by which a problem may need to be addressed (including lead times)
 - e.g. tipping point in barrier island submergence
3. In helping to identify realistic decision pathways, maybe discouraging use of some options that might otherwise have been considered
 - illustrated via barrier island studies
4. In assessing a maximum rate for increased coastal erosion processes
 - e.g. Calvert Cliffs illustration
5. In situations “where there is little tolerance for risk (e.g. new infrastructure with a long anticipated life cycle such as a power plant)” (NOAA, 2012).
 - e.g. possibly ‘overdesigning’ armor size for an exposed location like Point Judith

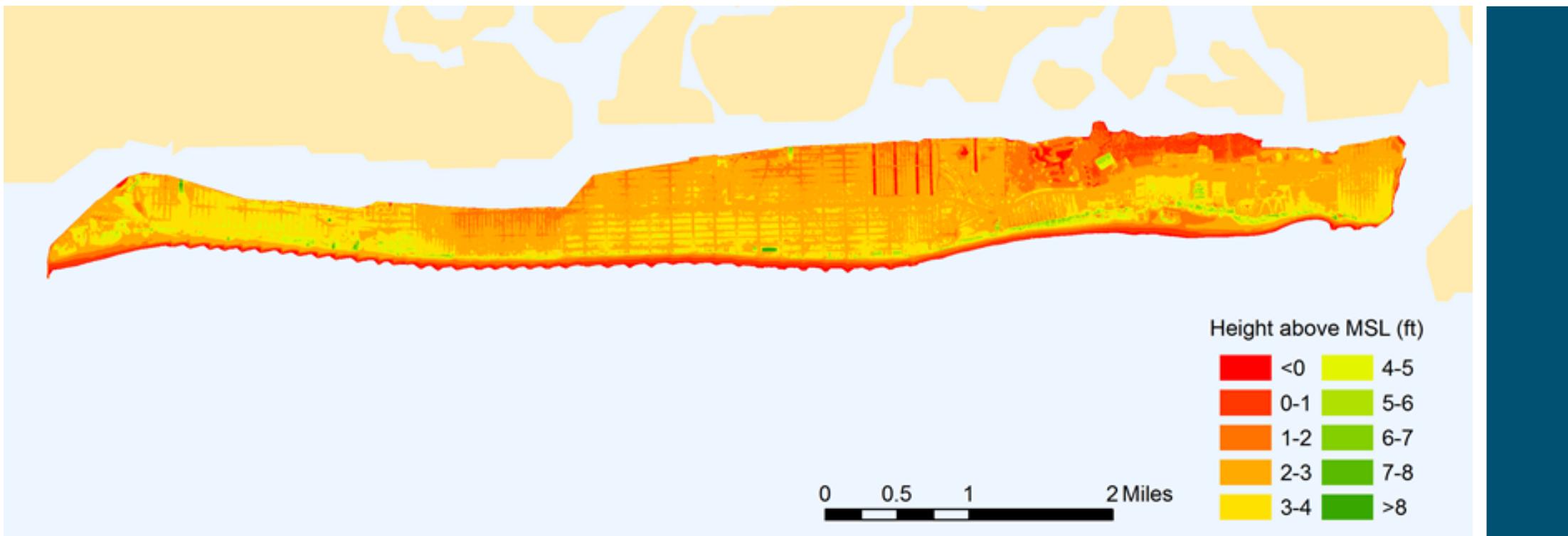
Proposed next steps for HR Wallingford team

Write up thinking to date on all sites

Illustrate value of thinking about a range of sea level change scenarios

Focus further analysis on Long Beach Island NJ

- Investigation of implementation of policy options, including long-term effectiveness of beach nourishment projects and identification of tipping points at which various options become viable / non-viable
- Determination of realistic decision pathways



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